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bart impact program

IMPACTS OF BART ON THE NATURAL ENVIRONMENT INTERIM SERVICE FINDINGS



The BART Impact Program is a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART).

The program is being conducted by the Metropolitan Transportation Commission, a nine-county regional agency established by state law in 1970.

The program is financed by the U.S. Department of Transportation, the U.S. Department of Housing and Urban Development, and the California Department of Transportation. Management of the Federally-funded portion of the program is vested in the U.S. Department of Transportation.

The BART Impact Program covers the entire range of potential rapid transit impacts, including impacts on traffic flow, travel behavior, land use and urban development, the environment, the regional economy, social institutions and life styles, and public policy. The incidence of these impacts on population groups, local areas, and economic sectors will be measured and analyzed. The benefits of BART, and their distribution, will be weighed against the negative impacts and costs of the system in an objective evaluation of the contribution that the rapid transit investment makes toward meeting the needs and objectives of this metropolitan area and all of its people.

BART IMPACT PROGRAM

IMPACTS OF BART
ON THE NATURAL ENVIRONMENT
INTERIM SERVICE FINDINGS



MARCH 1976

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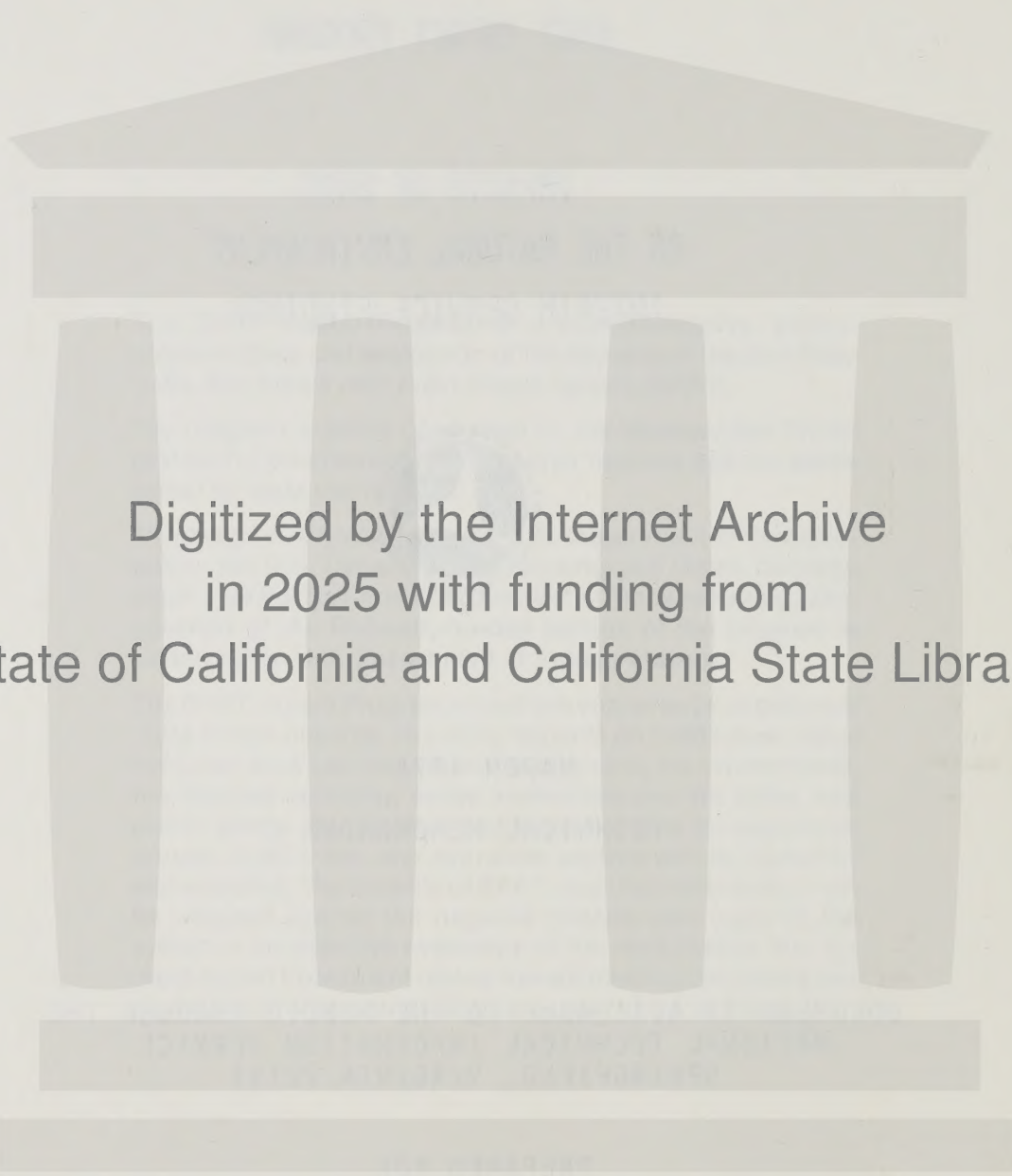
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PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

AND

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT



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GRUEN ASSOCIATES, INC.
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PREFACE

The PART Impact Program (BIP) is a comprehensive, policy-oriented study and evaluation of the impacts of the new San Francisco Bay Area Rapid Transit System (BART). The system's alignment and configuration are shown on the page following this preface. The BART Impact Program covers the entire range of potential rapid transit impacts, with major projects covering impacts on traffic flow, travel behavior, land use and urban development, economics and finance, social institutions and lifestyles, public policy and the environment. The incidence of these impacts on population groups, local areas, and economic sectors is being measured and analyzed. The benefits of BART, and their distribution, are being weighed against the negative impacts and costs of the system in an objective evaluation of the contribution that the rapid transit investment makes toward meeting the needs and objectives of the Bay Area and all of its people.

The Environment Project focuses on the effects of BART's physical presence on its surroundings. Environment is defined broadly to include five components: acoustic, atmospheric, natural, social and visual. Within each of these components the Environment Project will address two related phenomena:

- . Direct and indirect physical effects upon the environment brought about by the BART system
- . Social and psychological consequences of these physical changes to the environment

This report - Impacts of BART on the Natural Environment, includes an assessment of effects on biota, soils and geology, drainage and water systems. It is a technical paper containing a detailed presentation of natural environmental findings and the study methodology employed. This report is an interim document as study of BART's natural impacts is continuing. Phase I, covered in this report, concentrated on BART's natural effects on the physical dimensions of the Bay Area. However, measurements and assessment were made under interim BART operations. In Phase II additional assessment will be made as operational conditions change. Also in Phase II, people who live and work next to the BART system will be studied as to how they perceive and respond to impacts. And finally, in Phase II a comparison of BART's impacts with those of other means of providing a similar level of public transportation service will be made. The findings as derived here formed part of the basis for the development of Phase I conclusions regarding BART's overall environmental impacts. These interpretations are reported in the Phase I report - Environmental Impacts of BART.

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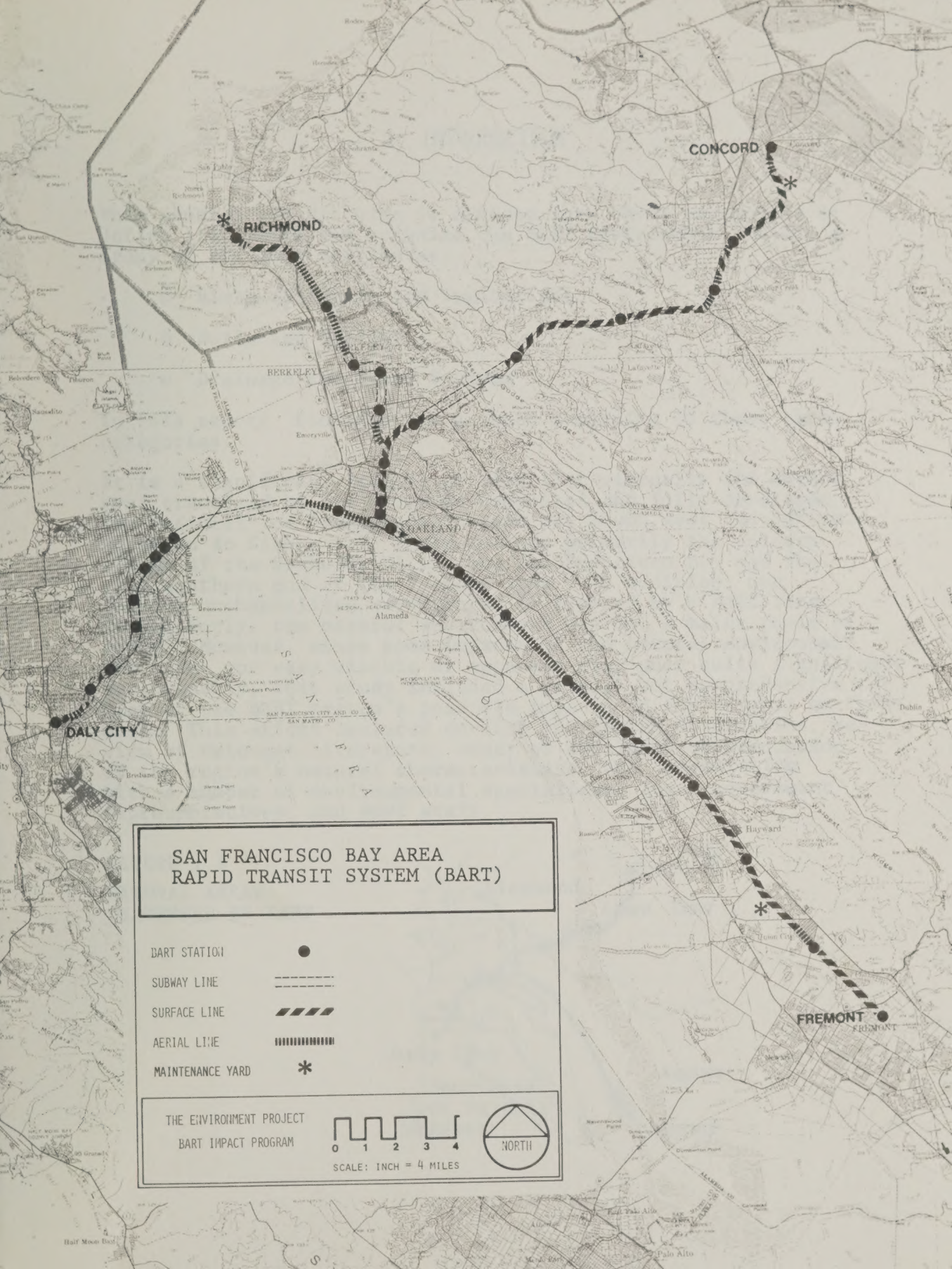
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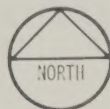
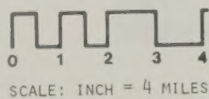
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SAN FRANCISCO BAY AREA
RAPID TRANSIT SYSTEM (BART)

- DART STATION ●
- SUBWAY LINE ————
- SURFACE LINE - - - - -
- AERIAL LINE ······
- MAINTENANCE YARD *

THE ENVIRONMENT PROJECT
BART IMPACT PROGRAM



I. INTRODUCTION

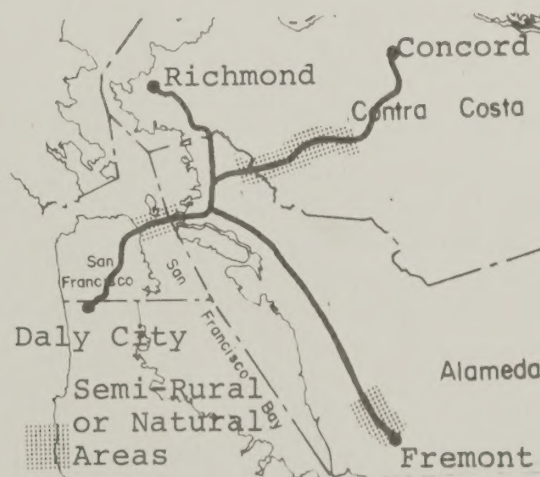
This general subject area is divided into three categories to define its limits and organize the BART Environment Project's study of its many attributes:

- o Biota (Wildlife and Vegetation)
- o Soils and Geology
- o Drainage and Water Systems

In this report, findings are grouped according to these three categories.

It is a significant feature of BART that virtually the entire area traversed by its lines is urbanized and fully developed. Few "natural" or "semi-rural" areas are found near the system. As shown in Figure I.1, these include primarily the eastern slopes of the Berkeley Hills, the San Francisco Bay and the very southern end of the Fremont line. In addition, one (minor) unchannelized watercourse is crossed by a BART line. Consequently, the natural environment was not a major topic of study. However, since some impacts on the natural environment are often not very visible or apparent even when quite significant ecologically, this study included a general but comprehensive review of the BART system's possible impacts on the natural environment. This effort included on-site and aerial observation, review of relevant literature, study of available documentation of the region's natural characteristics, and consultation with a number of environmental specialists, local government representatives, and BART staff.

FIGURE I.1
NATURAL AREAS
TRAVERSED BY BART



Data required for study of the temporary effects of BART construction on the natural environment were generally not available. Consequently, only a very general treatment of such effects was possible in this study, and emphasis is instead placed on present impacts of the BART structures and operations themselves.

II. SUMMARY

BIOTA

The term "biota" refers to the natural environment's living portion, including both vegetation (flora) and wildlife (fauna). These two aspects tend to be highly interdependent, with species of each acting as members of the same complex ecosystems. Consequently, the study of BART's biotic impacts was not organized by these two components. Instead, a five-subject organization was used to assure a more comprehensive coverage.¹

Methodology

The five subject areas included in the biota study were as follows:

- o Vegetative communities
- o Rare or endangered wildlife species
- o Diversity of ecological communities
- o Biotic productivity (plant and animal increase)
- o Nutrient cycling (flow of minerals)

Potential impacts within each of these subject areas were pursued through an initial screening of issues using MTC's existing Bay Area ecological inventory maps of environmental features. This was followed by direct observation of points of possible impact and interviews with specialists in specific fields such as marine biology. No detailed field data collection was required.

Issues and Findings

How has BART affected the vegetative communities along its route?

BART affected local vegetative communities both by removal during its construction and later replacement with new landscaping. No significant impacts on vegetative communities were caused by the removal of vegetation for construction. Although quantitative estimates of the extent of this removal were not available,

¹Approach adopted from Alan M. Voorhees & Associates, Inc. (1975) Interim Guidance Manual for Environmental Assessment for Use by HUD Field Office Personnel, Washington, D.C.: Office of Policy Development and Research, U.S. Department of Housing and Urban Development.

much was removed from the right-of-way in some locations. This included many large trees. However, the removal of trees along BART had no significant ecological impact due to the small and narrow areas affected relative to the size of their similar surroundings. The loss of mature trees in urbanized areas is primarily a visual aesthetic impact rather than an ecological one. Such aesthetic impacts were studied further in the project's assessment of effects on visual quality.²

Approximately \$6 million, or 0.4% of BART's total construction cost was spent on landscaping. This resulted in a varying but typically low to moderate level of landscaping, consisting primarily of small shrubs, street trees, and ground cover planting. No appreciable quantity of large trees was included. Most landscaping was placed at suburban stations and parking lots, as well as in some areas beneath aerial trackways. This landscaping has had no apparent effects on surrounding existing vegetation (pp. 27-31).

The BART landscaping program itself is of interest. Landscaping was originally planned to include only ground cover on slopes for erosion control, in keeping with the general principle of minimizing the BART system's operation and maintenance costs. However, public meetings during the planning process revealed substantial community concern with landscaping, and emphasis and funds for this purpose were subsequently increased.

As the program developed, Lawrence Halprin and Associates were retained as consulting landscape architect. This led to creation of a landscape design criteria manual.³ A dispute arose over the nature of Halprin's role, and he resigned before construction began. The design work continued without a landscape consultant. Ultimately, the landscaping design was carried out by eight different firms and installed under 33 separate construction contracts. After installation, maintenance responsibility was apportioned among the local jurisdictions as well as BART. These arrangements varied from place to place.

Much of the additional financial assistance required for the enlarged landscaping program was obtained from the U.S. Department of Housing and Urban Development. They funded 90 percent of the linear parkway demonstration in Albany and El Cerrito, as well as 50 percent of all other landscape design costs (p. 31).

²See Chapter VIII, BART Impacts on the Visual Environment.

³Lawrence Halprin and Associates (1964) Landscape Design Criteria, Rapid Transit: First Report, San Francisco: Bay Area Rapid Transit District.

Did BART disturb any rare or endangered species?

At least five rare or endangered species of wildlife are found in the San Francisco Bay area, as well as a number of ecologically important habitats.⁴ However, study revealed that the BART route avoids known sensitive environments containing these rare and endangered plant and animal species.

BART traverses the habitats of a great variety of other plant and animal species. These habitats surrounding the BART system consist primarily of vegetation and wildlife common to urban residential and street environment. The plant material typically is not native to the region and the wildlife communities consist primarily of small birds, mammals, and rodents not sensitive to an urbanized environment. Where BART traverses a more natural landscape, the vegetation is more indigenous to California and wildlife communities include some larger mammals and birds (pp.20-27).

Has BART affected ecological aspects such as diversity, reproduction, and the food chain?

There is great diversity within the plant and animal communities affected by BART. This implies that the changes introduced by BART are likely to have only limited effects on the total communities surrounding the BART right-of-way. There was no indication of any significant impact on diversity. Similarly, the BART system did not significantly reduce regional biotic productivity (reproduction) or nutrient cycling (food chain). These important ecological processes were reduced only on the BART right-of-way; the significance of this impact is negligible, considering the limited area of the right-of-way in contrast to its surroundings.

An issue of particular interest relative to productivity was whether heat transmitted from the Transbay Tube into the cold bottom waters of San Francisco Bay would upset established marine ecological systems. Experts consulted judged that such effects on aquatic systems were negligible, only slightly increasing productivity if at all. Similarly, since the tube is actually in a now silted-over trench beneath the Bay floor, it poses no barrier to migrating bottom-dwelling organisms such as crabs (p. 34).

⁴Metropolitan Transportation Commission (1974) Draft Environmental Impact Report for the Metropolitan Transportation Plan, Berkeley: Metropolitan Transportation Commission.

SOILS AND GEOLOGY

This category encompasses BART's impacts on the non-living portions of the natural environment. Water systems are excluded and treated as a separate category, which follows this section.

Methodology

The fundamental concern in the soils and geology category is stability. Impacts occur where construction causes soil and geologic conditions to become less stable and therefore more likely to shift, for example by landslides or erosion. In addition, the use or consumption of unique or valuable geological resources is of concern here. Consequently, this study included review of the following subtopics:

- o Slope stability
- o Valuable geological resources
- o Unique geological features
- o Impermeable strata
- o Weathering

In addition to BART's potential impacts on soils and geology it is also possible that geological processes such as consolidation or earthquakes could have substantial effects on BART itself. This study therefore also encompassed the study of three additional subtopics:

- o Consolidation
- o Seismic activity
- o Subsidence

Potential impact topics were first screened through interviews with officials of BART and communities along the lines. Maps of Bay Area geologic structures were also reviewed to identify locales of steep slopes, unstable soils and other significant natural features. Further familiarity was gained through an aerial reconnaissance of the BART line, using photography as well as direct observation to identify points of landslide, erosion, sedimentation and major landform alteration. Additional on-site observations and interviews focused on areas in which potential impacts were identified by the screening process. No further field data collection was required.

Issues and Findings

Did BART construction create new dangers of landslide or erosion?

Major hillside grading for BART construction was required in only one general area, that of the eight-mile Orinda-Walnut Creek section of the Concord line. In this area the topography is steep and rugged in contrast with the generally flat terrain throughout the remainder of the BART right-of-way. Geologic conditions in this hilly area are unusually unstable; the "Orinda formation," a highly expansive, uplifting, easily weather-weakened clay structure, is prevalent and highly susceptible to landslides.

As a part of BART construction from Orinda to Walnut Creek, a major highway (State Route 24) through the hills was widened to allow placement of BART tracks in its median. This required extensive new slope cuts in the Orinda formation, particularly at the Orinda station where over four million cubic yards of soil were removed. Continuing, although generally minor, landslides and erosion have resulted.

In the Hayward-Fremont area, heavy rains in the first two years following construction of BART trackway embankments caused severe erosion and gullyng of the four and one-half miles of embankment there. This necessitated extra effort by BART in sediment removal and slope repair. However, the problem has since been controlled with ground cover planting. No other landslide or erosion problems were found (p. 54).

Were any unique or valuable geologic resources lost as a result of BART construction?

The BART system is not located in areas of special geologic interest. Although extensive hillside excavations were made between Orinda and Walnut Creek, the hills and valleys altered are not unique either within or beyond the Bay Area. These excavations generally only widened existing freeway cuts rather than making basic topographical changes. Such alterations were therefore judged not to be significant disruptions to special geologic features.

Most of BART's construction was near the ground surface, primarily above the water table. In other areas where deeper construction was employed, notably the downtown subways, there was no indication of effects on vertical or lateral ground water flow. Although data on depths of impermeable strata were not available, their presence is doubtful since most of BART's subway mileage was built in areas of deep silt and bay mud (pp. 51-52).

Is BART subject to present or potential dangers of differential settlement or earthquake?

There is evidence that the unstable soil conditions in the Orinda-Walnut Creek area are causing slight deformations in the new highway pavement and BART track alignment. This deformation is also found in the Orinda station parking lot. It is caused by seepage of ground water, and will be a continuing maintenance problem.

Apart from this situation, BART facilities have suffered no significant impacts of differential settlement or surface deformation (pp.55-56). This was due at least in part to the emphasis given to this potential problem during BART's design. Special design features included the following:

- o Pilings under trackway columns, to minimize settlement;
- o Simple span beam design for elevated trackways, to simplify any track realignment required later;
- o Granular base material under the Transbay Tube, spreading the weight evenly over the soft Bay mud.

There is a widely acknowledged potential for seismic activity in the Bay Area. The BART tracks cross one major fault zone, the Hayward fault, at the western end of the Berkeley Hills tunnel. Consequently, BART's design included a number of measures to minimize the effects of shear zone movement on its facilities and operations (pp.56-58).

- o Berkeley Tunnel: easily replaceable short concrete tunnel lining sections, larger diameters, maximum distance between the two one-way tunnels, cross-over tracks connecting the two tunnels, and fault deflection meters for early warning.
- o Elevated trackways: simple span construction, with pin connections between beams and columns to prevent displacement.
- o Transbay Tube: granular base to mitigate liquefaction effects.

DRAINAGE AND WATER SYSTEMS

The emphasis of this assessment has been on the effects of BART facilities on local natural water systems, particularly near BART's parking lots. Since most watercourses crossed by BART

were already channelized and lined, few impacts on natural water systems were to be expected. However, there are a variety of potential impacts which do not require the immediate presence of natural streams. Potential types of impact studied included the following:

- o Surface drainage
- o Storm water flooding
- o Water quality
- o Sedimentation
- o Aquifer yield
- o Ground water recharge

In addition, potential impacts on BART itself from the leakage or failure of water impoundments were investigated.

Methodology

In this study primary reliance was placed on interviews with public works officials of communities along BART. In addition, interviews were held with officials of BART and its engineering design consultant who had been involved in this aspect of the original BART design. Aerial photographs were also reviewed and on-site inspections were made in locations of possible impact. Finally, MTC ecological inventory maps were used to identify ground water recharge areas.

Issues and Findings

Has rainfall runoff due to BART facilities been beyond local storm drainage capacity?

Each of BART's parking lots has from two to eight acres in paved or impermeable surface area, thereby increasing local rainfall runoff. In all cases BART construction included provision of adequate storm sewer capacity for this additional flow. This effort went so far as to increase, beyond BART's requirements, the size and capacity of nearby municipal storm sewers in two cities.

No major flooding has occurred due to BART. Some minor flooding has occurred at points in Richmond, El Cerrito, and Orinda, generally due to temporary clogging of drainage culverts and ditches as well as inaccuracies in landscape grading. Most of this flooding has been confined to BART property, and no significant property damage or personal danger has been noted (PP. 71, 74).

Have contaminants in BART runoff waters adversely affected public water supplies or natural habitats?

Inspection of aerial photographs, interviews with local officials, and site inspection revealed only one indication of significant sedimentation effects either from BART construction or operations. This was in the case of the trackway embankments between Hayward

and Fremont, which were heavily eroded by rains before ground cover planting could become established. The resulting sediment was deposited in local drainage channels and, according to a Hayward city spokesman, contributed to local storm sewer maintenance costs. This condition was ultimately corrected by ground cover planting.

Virtually all runoff from BART facilities is channeled into lined storm drains with ultimate discharge into San Francisco Bay. At the points of discharge BART's contributions to total volume are insignificant. In one instance, a natural pond at the Fremont station, aquatic life was present and conceivably could have been affected by contaminants in parking lot runoff. However, there was no indication of such effects.

BART is not located in the region's primary ground water recharge zones, and in only one area traversed (Orinda-Lafayette) does surface drainage contribute to local water supply. Even in that area, the eight-acre total land surface occupied by BART's parking lots is an insignificant loss in permeable surface. Aquifer yields were likewise unaffected since the scale and depth of BART-related earthwork was not sufficient to cause such impacts. Major grading occurred only in the Orinda-Walnut Creek area, and no significant aquifers were exposed (pp.71-74).

Is any of the BART system located so as to be endangered by dam failures?

Four artificial impoundments are located upstream and near portions of BART's Fremont line. According to the Alameda County Office of Emergency Services, at least three of these may be large and close enough to damage the BART facilities in the event of a dam failure such as might occur in a major earthquake (pp.75-76). The exact earthquake magnitude required to cause such a catastrophe is not known, but is probably so large as to be of extremely low probability. Further study of this potential danger is included in a current State of California program on possible effects of earthquake-related dam failures.⁶

⁶State of California, Office of Emergency Services, as authorized under Senate Bill 896.

III. BIOTA

DEFINITION AND SCOPE

Biota (plants and wildlife, or "living systems") compose the living portion of the natural environment. Impacts on biota caused by BART construction and operation are measured by the changes made to the habitats and productivity of living organisms, both within the right-of-way and in immediately adjacent areas.

The primary concern in assessing changes to biota is understanding the effects of change on ecological balance from both a local and regional perspective. An impact from BART operations and construction on biota, therefore, is any change to the habitat of living organisms which alters an existing balance in the environment. The severity of an impact is determined by the degree to which it changes an existing ecological system, and the degree to which that change is viewed as beneficial, neutral or adverse. The potential for BART construction and operations to change natural habitats was investigated under the following major topics:

- o plant and animal species,
- o plant and animal community types,
- o plant or animal diversity,
- o plant or animal productivity, and
- o nutrient cycling.

RESEARCH QUESTIONS AND RATIONALE

Research questions were based on an evaluation of fundamental biotic relationships within the natural environment and the potential effects on these relationships induced by BART construction and operations.

Research questions for the assessment of BART impacts on biota evolved during the course of the study. The initial research questions focused on specific areas of concern and potential problems that had been identified at the outset of the study. As the investigation proceeded, however, and the number of specific issues identified increased, it became clear that a more general categorization of research questions was needed. These categories were necessary to include all the traditional concepts of potential biota-related concerns. The focus of the research questions was shifted from an inventory of problem areas to an organized framework in which individual problems could be placed in context with the overall function and structure of the natural environment.

PLANT AND ANIMAL SPECIES

Plant and animal species within and surrounding the BART right-of-way were evaluated to determine possible effects attributable to BART construction and operations. Of special concern are effects on rare or endangered plant and animal species. The following research questions were investigated.

- 3.1 Are there rare and/or endangered species present requiring protection?
- 3.2 Are there species present which are particularly susceptible to impact from BART construction?
- 3.3 Are there species of vegetation present within the BART right-of-way, the loss of which would deny food or habitat to important wildlife species?
- 3.4 Are there nuisance species of plants or animals for which conditions will be improved by the project?

VEGETATION AND WILDLIFE COMMUNITY TYPES

Of more general significance than individual species of plants and animals added or removed by BART construction and operation are the vegetation communities in which they reside. Stability within these communities depends on interactions among member species. It is important, therefore, to address the effects of BART on the maintenance or disruption of vegetation community types. The following research questions were investigated:

- 3.5 Does BART affect any unusual populations of plants and animals or disjunct populations of organisms exhibiting genetic variability that may be of scientific interest?
- 3.6 Are there vegetative and wildlife community types which are particularly susceptible to impact from BART construction and operations?
- 3.7 Are there community types present, the loss of which would deny food or habitat to important wildlife species or a substantial number of different animals?

PLANT OR ANIMAL DIVERSITY

The effect of BART construction on plant and animal diversity was investigated. Areas which contain a great diversity of species are more stable, have greater resistance to changes induced by an activity such as BART construction and operations, and are therefore less likely to exhibit symptoms of environmental impacts than an area which exhibits very little diversity in species. When there is uniformity in species types, it implies the existence of severe environmental constraints within which only a few species can survive. In such cases, the effects from BART may upset very delicate natural balances causing major shifts in species composition. The following research questions were investigated.

- 3.8 Is there substantial diversity in the natural community as reflected in:
 - (a) Number and type of plant or animal species present?
 - (b) Three dimensional arrangement of plant species present?
- 3.9 Is there diversity of any vegetative community type so low as to make it particularly susceptible to impact from BART?

- 3.10 Is the diversity of any vegetative community type affected by BART high enough to make it especially valuable as a wildlife habitat?

PLANT AND ANIMAL PRODUCTIVITY

Plant and animal productivity within the BART right-of-way was evaluated to determine where unusually productive resources were eliminated. BART's impacts on biota and wildlife will tend to be greatest in areas with the highest productivity for plant and animal species. The following research questions were investigated.

- 3.11 Will BART construction preclude use of naturally fertile land resources?
- 3.12 Will human activity (BART) cause loss of nutrients from the site and lower its fertility?

NUTRIENT CYCLING

Nutrient cycling is one of the basic natural processes affecting ecological balance. It determines the productivity and distribution of plant and animal species within a natural area and affects the regeneration rate in which a disturbed area recovers from the removal of existing vegetation. The degree to which BART construction and operation affected nutrient cycles was assessed using the following research questions.

- 3.13 Will project activity disrupt the natural flow of materials necessary for plant and animal growth?
- (a) Impoverishing one area by causing its nutrients to flow from it?
 - (b) Polluting another area by an over abundance of nutrients released from the project area?

METHODOLOGY

The methodology used in assessing impacts on biota from BART construction and operations had three steps: First, an inductive open search phase in which many individuals knowledgeable of the effects of BART were contacted and areas were selected for further study; second, a more refined search phase in which the potentially critical areas within the system just identified were studied in detail; and finally, an evaluation phase in which this information was synthesized and conclusions drawn.

INDUCTIVE PHASE

During the first part of the study a search was conducted of possible sources of information concerning impacts on biota. This search included BART, government, and university personnel. The purpose of this phase was to refine the scope of the study and uncover specific issues requiring further investigation.

In addition to contacting various sources concerning possible environmental issues, oblique aerial photographs were taken over most of the BART line. There was no pattern in taking these photographs except to record every station with a parking lot and other areas of particular environmental interest (e.g., open space) along the BART line. These photographs were then categorized according to general location and condition of interest.

The final task during this relatively loosely structured first stage was to interview city staff members in all cities served by BART for their opinions and observations concerning local impacts on biota, relating either to existing vegetation or landscaping introduced by BART.

REFINED SEARCH PHASE

The inductive phase uncovered several issues (or impact sub-categories) of potential significance. In the following phase, these were investigated by several means including direct observation, detailed interviews and a document and literature review. Care was taken to verify findings by using more than one method of investigation wherever possible. This triangula-

tion significantly increased confidence in particular conclusions. This was particularly important for the largely subjective issues treated in this category of impact.

FINAL SYNTHESIS

The line between the search phases and final synthesis is elusive. As more and more information was accumulated and conclusions drawn concerning specific identifiable issues, interrelationships began to appear. During this synthesizing phase more emphasis was placed on relating each impact category into a more comprehensive structure of biotic concerns. It was necessary here to find the underlying structure within the ecosystems disrupted by BART construction and operations. As this effort developed, it became apparent that the current HUD effort to develop guidelines for environmental impact study provided a useful basis.¹

The relevant portion of the HUD approach is a comprehensive summary of fundamental biotic interrelationships within the natural environment. Its focus is on the meaning of observed changes resulting from BART's construction and operations. For example, BART's removal of one kind of plant material from the existing right-of-way and its replacement with landscaping of different material is of less concern in this approach than is a description of the effects of this change in terms of biota productivity, diversity, or changes affecting rare or endangered species.

In this final analysis, therefore, the specific changes which had been observed were related to the internal cycling of natural systems. This allowed determination of whether these observed changes had a significant effect on the surrounding environment.

¹ Alan M. Voorhees & Associates, HUD's Areas of Environmental Concern, prepared for the U.S. Department of Housing & Urban Development, Washington, D.C. (July, 1974).

THE BIOTIC ENVIRONMENT WITHOUT BART

This study's findings are based on the assumption that the following biotic environment would exist in the corridor if BART were not present. This establishes the baseline from which BART's net impacts are assessed. Only above-ground sections are described since underground portions of the line were virtually all beneath existing streets and had no effect on biota.

"R" LINE (MAC ARTHUR TO RICHMOND)²

Prior to BART, biotic resources along the "R" line consisted of full grown trees and other mature urban vegetation along the Southern Pacific right-of-way. Since the area was already urbanized, natural plant communities had previously been removed. The construction of BART resulted in the removal of most existing vegetation within the right-of-way.

"A" LINE (FRUITVALE TO FREMONT)

Without BART, biotic resources along the "A" line would consist of scattered large trees and other forms of urban vegetation. The area between South Hayward and Fremont would still consist of agricultural lands with a minimum of vegetation.

"C" LINE (MAC ARTHUR TO CONCORD)

Without BART and the extensive grading required for the expansion of Route 24 from six to eight lanes, there would be approximately eight to ten more acres of indigenous live oak stands and grassland in the area adjacent to the Orinda station and along the corridor between Orinda and Walnut Creek. Between Mac Arthur station and the West Portal of the Berkeley Hills tunnel and between Walnut Creek and Concord some large trees and other forms of urban vegetation would exist in the BART corridor if the system had not been constructed.

²The line designations "R", "A", "C" and "M" are those used by BART in its internal operations and are here cited only for consistency and ease of notation.

"M" LINE (GLEN PARK TO DALY CITY)

Without BART the biotic conditions along the "M" line would be unchanged. For most of its route above-ground BART is elevated along the Route 280 right-of-way side slopes. The design of Route 280 did not originally incorporate nor was it substantially altered by BART. Therefore, if BART had not been built, the right-of-way slopes would be unchanged.

OTHER CHANGES

Without BART there is a substantial possibility that Route 4 between El Sobrante and Concord would have been significantly upgraded.³ This would have resulted in a loss of indigenous vegetation along the right-of-way. However, this would have been of negligible importance due to the dry grassland found throughout the area.

³ McDonald & Smart, Inc., A Generalized NoBART Transportation Alternative, prepared for the U.S. Department of Transportation, Washington, D.C. (May, 1975).

FINDINGS

IMPACT ON PLANT AND ANIMAL SPECIES

3.1-3.4 - While BART traverses the habitats of a great variety of plant and animal species, no rare or endangered species have been affected.

The plant and animal species affected by BART construction and operations include those species present on the right-of-way prior to BART construction, vegetation species added as landscaping to the BART right-of-way after construction, and wildlife species adopting BART landscaping or structures as a habitat. The impacts of BART on these three major plant and animal groupings were addressed for the following research questions.

- 3.1 No rare or endangered plant or animal species were found to occur within the BART right-of-way. However, such species are found within the general area surrounding the BART corridor.

This finding responds to the research question: Are there rare or endangered species requiring protection present? Supporting documentation follows.

The study area contains numerous wildlife habitats of ecological significance, as well as five rare and endangered wildlife species. Table III.1 lists the wildlife habitats of the study area and indicates their environmental significance.⁴ None of these recognized ecological areas was directly affected by the BART system. Furthermore, secondary impacts are unlikely since the areas are either legally protected from urban encroachments or are not located in areas that could be affected by secondary growth induced by BART.

Figure III.1 illustrates the area occupied by the endangered rare wildlife for the entire metropolitan area. The BART system misses all potential areas occupied by rare and endangered species excepting a snake, the Alameda Striped Racer. This species, which prefers rocky outcroppings in woodland, is known to be present east of the study area on Sunol Ridge northeast of Fremont. It is unlikely that the species was directly disturbed by the development of the BART system as the preferred habitat of the snake probably occurred very infrequently if at all along the alignment. However, if the

⁴Wallace, McHarg, Roberts & Todd, Environmental Impact Assessment Procedure, Regional Transportation Plan. Prepared for the Metropolitan Transportation Commission, 1973.

Table III.1

PLANT COMMUNITIES AND HABITATS OF ECOLOGICAL IMPORTANCE *

<u>Community</u>	<u>Acres Where Known</u>	<u>Unusual Species</u>	<u>Ecological Importance</u>
<u>Mountains</u>			
San Bruno Mountain		542 plant species including Umbellaria California native grasses	Presence of rare, endangered and unique flora
Mount Diablo	10,000		Transitional zone for vegetation types
<u>Ridges</u>			
Los Trampas Ridge		Chaparral	Undisturbed example
El Sobrante Ridge		Manzanita	Typical, undisturbed plant association
Jasper Ridge		Over 1/2 of all vascular plants in California present	Excellent study area
<u>Valleys</u>			
Briones Valley	2-3,000	Indigenous vegetation	Undisturbed valley
<u>Promontories and Islands</u>			
Pt. San Pablo		Grassland, live oak, laurel	Undisturbed grass and oak communities
Tiburon Peninsula		St. Hilary Wildflower	Serpentine endemics

*Wallace, et al., Ibid., Areas of Unique Value Map No. N-134.

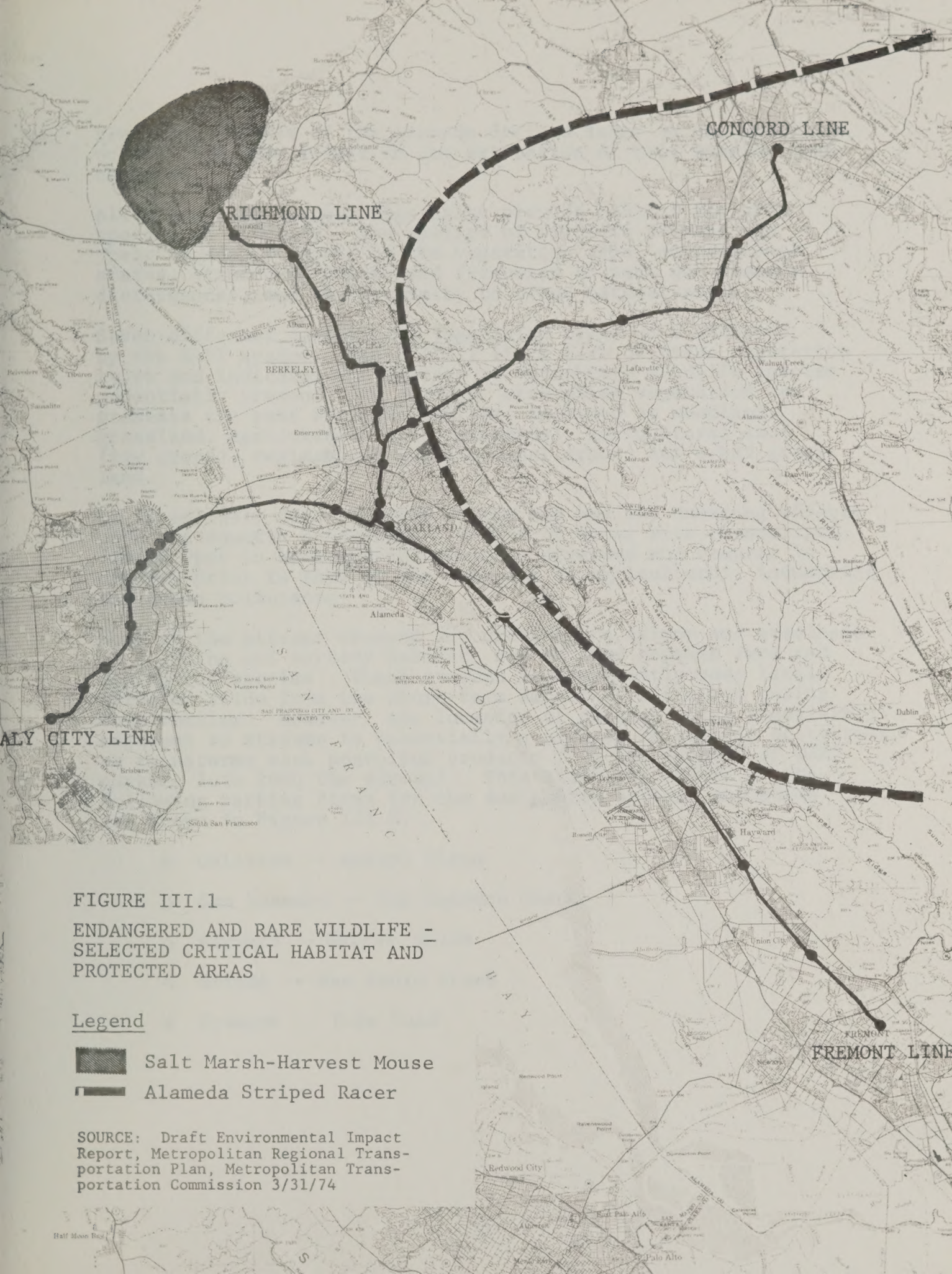


FIGURE III.1

ENDANGERED AND RARE WILDLIFE -
SELECTED CRITICAL HABITAT AND
PROTECTED AREAS

Legend

-  Salt Marsh-Harvest Mouse
-  Alameda Striped Racer

SOURCE: Draft Environmental Impact
Report, Metropolitan Regional Trans-
portation Plan, Metropolitan Trans-
portation Commission 3/31/74

remaining habitat of the Alameda Striped Racer is not protected, urbanization may result in the extinction of this species from the area.

All areas that contain vegetation provide habitat for some species of wildlife. The species of wildlife present and their abundance depend on the vegetation type, successional status, structure, degree and frequency of past and present disturbances, and the proximity to other natural areas.

Seven different terrestrial vegetation types were affected by the BART system. Table III.2 lists each of these vegetation types and indicates the classes of vertebrate wildlife species potentially present. In general, streamside vegetation represents the best wildlife habitat, followed by woodland, grassland, agricultural land (orchards), agricultural land (row crops), residential-institutional areas, and urban grassland.

It is unlikely that the BART system has had any damaging effects upon the aquatic ecosystems. Bodies of water were channelized, dammed, put in underground culverts, diverted and reduced in quality prior to BART by the addition of agricultural, industrial and urban pollutants.

None of the streams crossed are critical to salmon and steelhead as spawning and nursery habitat, nor do they contain rare and endangered species. These streams have evidently been little affected aside from the short-term impact of siltation during construction. However, the location of parking areas immediately adjacent to streams is potentially a problem to aquatic ecosystems, as rainstorms wash petroleum products from the asphalt of BART parking lots into the streams. This situation occurs at the following parking sites for the designated streams and ponds (as shown in Figure III.2):

- o Coliseum -- Arroyo Virgo
- o San Leandro -- San Leandro Creek
- o Hayward -- Sulfur Gulch
- o Orinda -- San Pablo Creek
- o Fremont -- Tule Pond

Table III.2

CLASSES OF VERTEBRATE WILDLIFE POTENTIALLY PRESENT BY TERRESTRIAL VEGETATION TYPE*

Vegetation Type	Large Mammals	Small Mammals	Reptiles	Amphibians	Waterbirds	Marsh & Shore Birds	Upland Game Birds	Birds of Prey	Songbirds
Streamside	x	x	x	x	x	x	x	x	x
Woodland	x	x	x				x	x	x
Grassland	x	x	x				x	x	x
Agricultural (orchard)	x	x	x				x	x	x
Agricultural (row crops)	x	x	x				x	x	x
Residential-Institutional		x						x	x
Urban Grassland		x						x	x

*Wallace, et al, ibid, Preferred Habitats of Residential or Nesting Wildlife Species, Map Sheet N-11A.

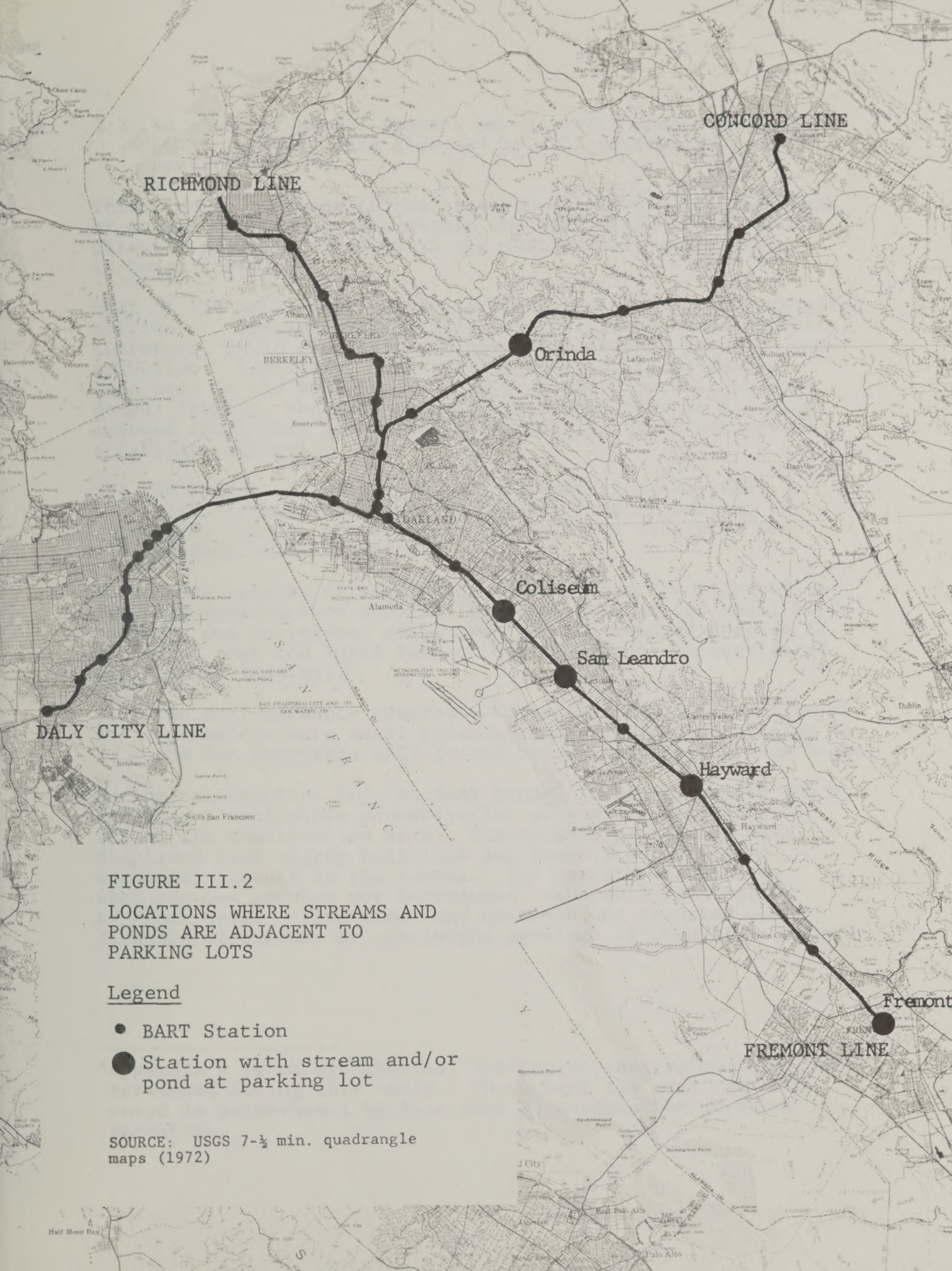


FIGURE III.2

LOCATIONS WHERE STREAMS AND
PONDS ARE ADJACENT TO
PARKING LOTS

Legend

- BART Station
- Station with stream and/or pond at parking lot

SOURCE: USGS 7- $\frac{1}{2}$ min. quadrangle
maps (1972)

- 3.2 No plant or animal species particularly susceptible to human activity were affected by BART construction or operations.

This finding responds to the research question: Are any plant or animal species present within the BART right-of-way or directly adjacent areas which are particularly susceptible to human activity?

Most of the BART right-of-way is located within highly urbanized corridors. Species particularly susceptible to human activity, therefore, would generally not have been present prior to construction. Similarly, such species were not found to have been used in the BART landscaping program. There is no evidence, finally, that any such species would have or did adopt exposed facilities such as BART landscaping or structures as a habitat (Harvey)⁵.

- 3.3 No species of vegetation was present along the BART right-of-way whose loss would deny food or habitat to rare, unique, commercially valuable, or otherwise important wildlife species.

While many species of vegetation removed from the right-of-way for BART construction supplied food and habitat for small birds, rodents, and occasional small mammals, the removed species is so common that the small loss of habitat cannot be considered significant (Harvey).

- 3.4 The only nuisance species affected by BART construction or operations were small rodents (rats) which concentrated in the San Francisco BART tunnel before Transbay service began.

During construction for the BART tunnel in San Francisco there occurred a noticeable concentration of small rodents (rats) within the construction area. The rodents presumably were displaced from nearby buildings and found food left from workmens' lunches in the tunnel. The rodents disappeared when regular service was introduced, apparently distracted by train noise. Interviews and observations revealed no indication of further or continuing problems of this kind (Walton).

⁵Appendix B is an alphabetical listing of the professionals interviewed during this study. Throughout the text they are noted in parentheses by last name as sources for previous information.

IMPACT ON PLANT AND ANIMAL COMMUNITY TYPES

3.5-3.7 - No significant biota impacts were caused by the removal of vegetation for BART construction in areas outside the right-of-way. Much of the vegetation removed was replaced by landscaping along the right-of-way and in most stations and parking lots.

Description of Change

Vegetation and Wildlife Communities Removed

The vegetation removed from the BART right-of-way included residential-institutional, urban grassland, agricultural, woodland, and stream site varieties. Figure III.3 shows the location of this vegetation and Table III.3 identifies the vegetation types specifically removed from BART stations for construction of parking facilities. Appendix A provides a further description of this vegetation. Table III.4 includes common wildlife habitats in the area affected by BART.

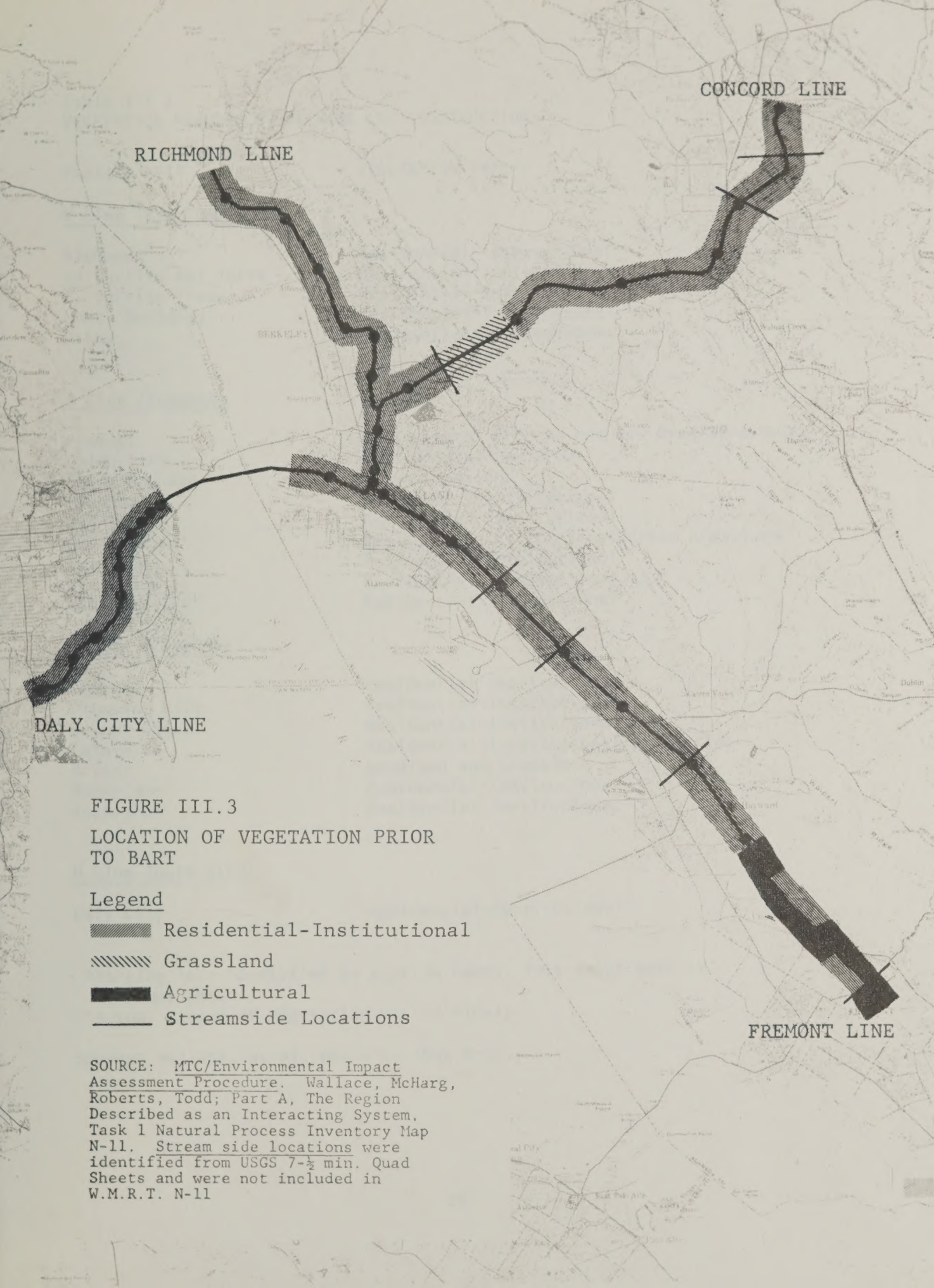
Vegetation Added Through Landscaping

The cost of BART landscaping was reported to be about \$6 million or 0.4 percent of BART's \$1.6 billion total cost (Moses). This consisted primarily of small shrubs, street trees, and ground cover planting. Most landscaping was placed at stations and parking lots and in many areas underneath aerial trackway structures. The landscaping did not include any appreciable quantity of mature plant material.

The emphasis on landscape design for BART went through several stages. Landscape treatment for the BART system was originally considered only as an erosion control measure. There was concern to minimize all aspects of BART that would require continuing maintenance costs in the future (Moses). However, as planning progressed and local community interest concerning landscaping was expressed at public meetings, the BART staff increased the emphasis and money allocated to the landscape program.

Assistance for the landscape program was obtained from the U.S. Department of Housing and Urban Development (HUD) Office of Community Planning and Development.⁶ Federal funding paid for 90 percent of a demonstration linear parkway plan in El Cerrito and Albany and 50 percent for all other landscape design costs (Moses).

⁶Urban Beautification Demonstration Grant, Section 708(c) of Title VII of the Housing Act as amended to the Bay Area Rapid Transit District.



RICHMOND LINE

CONCORD LINE

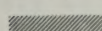
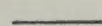
DALY CITY LINE

FREMONT LINE

FIGURE III.3

LOCATION OF VEGETATION PRIOR
TO BART

Legend

-  Residential-Institutional
-  Grassland
-  Agricultural
-  Streamside Locations

SOURCE: MTC/Environmental Impact Assessment Procedure. Wallace, McHarg, Roberts, Todd; Part A, The Region Described as an Interacting System, Task 1 Natural Process Inventory Map N-11. Stream side locations were identified from USGS 7- $\frac{1}{2}$ min. Quad Sheets and were not included in W.M.R.T. N-11

Table 111.3
VEGETATION REMOVED BY PARKING LOT CONSTRUCTION

PARKING LOT*	VEGETATION TYPE**
<u>R Line (Richmond)</u>	
Richmond	Residential-Institutional
El Cerrito del Norte	Residential-Institutional
El Cerrito Plaza	Residential-Institutional
North Berkeley	Residential-Institutional
Ashby	Residential-Institutional
<u>A Line (Fremont)</u>	
Fremont	Agricultural-Orchard and Row Crop/Streamside
Union City	Agricultural-Row Crops
South Hayward	Urban Grassland
Hayward	Residential-Institutional
Bay Fair	Residential-Institutional
San Leandro	Residential-Institutional/Urban Grassland
Coliseum	Residential-Institutional
Fruitvale	Residential-Institutional
Lake Merritt	Residential-Institutional
<u>C Line (Concord)</u>	
Concord	Residential-Institutional
Pleasant Hill	Residential-Institutional
Walnut Creek	Residential-Institutional
Lafayette	Residential-Institutional/Streamside
Orinda	Woodland and Grassland
Rockridge	Residential-Institutional
MacArthur	Residential-Institutional
<u>M Line (Daly City)</u>	
Daly City	Residential-Institutional

*Parking lots identified by station names; lots exist only at stations named.

**Actual extent of vegetation varied widely.

Source: Wallace, et al, op. cit., Map N-11.

Table III.4
WILDLIFE HABITATS IN THE STUDY AREA*

HABITAT TYPE	UNUSUAL SPECIES	ENVIRONMENTAL IMPORTANCE
<u>Open Water</u>	striped bass	warm water streams; extra-ordinary wildlife waterway
<u>Marshes</u>		
Alviso Marsh	duck, tern, rail, striped bass, white sturgeon, red-bellied harvest mouse	California nesting areas for both clapper rail and red-bellied harvest mouse
Bair Island & Greco Island	waders and shorebirds	nesting areas for least terns and white-tailed kite
Palo Alto Marsh	plovers, turnstones, sandpipers, killdeer	important for variety of shorebirds
North Richmond	clapper rail and salt-marsh harvest mouse	habitat for endangered species
Emeryville	marsh bird	somewhat disturbed marsh but haven near urbanized area
<u>Land Areas</u>		
Crystal Springs	San Francisco garter snake	endangered species
Sunol Ridge	Alameda striped racer	listed as rare species
<u>Beaches</u>		
Point Lobos	sea lions, sea birds, diversity of marine life	wide diversity of creatures adjacent to city

*Wallace, et al, ibid., Preferred Habitats of Resident or Nesting Wildlife, Map No. N-11A.

The landscaping program for BART was completed under 33 individual contracts using eight landscape architectural design firms (Hawley). The program was originally under the overall direction of Lawrence Halprin and Associates who prepared a report concerning landscape design criteria in July 1964.⁷ In 1966, however, Halprin resigned and the position of consulting landscape architect was not reestablished. Figure III.4 shows the intensity of landscaping as of April 1975.

One of the most significant concepts developed during the landscape design for BART was the Linear Parkway. In 1968 a demonstration grant was obtained from the Office of Community Planning and Development of the Department of Housing and Urban Development (HUD) to finance the construction of a 2.7-mile linear parkway in parts of Albany and El Cerrito. This concept was later applied in Concord where the city requested BART staff to redesign portions of the line to change it from a berm to an aerial structure. A short length of linear parkway similar to but less elaborate than the parkway in Albany and El Cerrito was then constructed.

Description of BART-related Impact

No significant impacts to vegetation and wildlife community types have resulted from BART construction and operations. Impacts not considered significant include noise effects to songbirds, and migration route impacts to small rodents and mammals.

This major finding responds to research questions stated earlier, addressing impacts from BART construction and operation on vegetation and wildlife community types. Supporting findings and documentation follow.

3.5 Unusual populations of plants and animals exhibiting genetic variability of scientific interest were not found adjacent to the BART right-of-way.

There were no unusual populations of plants and animals existing within the right-of-way prior to BART construction. For the majority of its length, the corridor was located within existing development. The included plant and animal communities, therefore, were those common to urbanized places within the Bay Area (Harvey). Habitats for recognized rare and endangered species are located well away from the BART corridor.⁸ Where the BART corridor traverses rural or only partially developed areas (between Orinda and Walnut Creek on the Concord Line

⁷Lawrence Halprin & Associates, op.cit., July 1964.

⁸Wallace, et.al., op.cit., "The Region Described as An Inter-acting System". Task 1, Natural Process Inventory.



FIGURE III.4
EXISTING LANDSCAPE DEVELOPMENT

Legend

-  Extensive Landscaping
-  Average Landscaping
-  Erosion Control Landscaping
-  Subway or Tunnel
-  Landscaping Associated with Freeways

SOURCE: Aerial Photographic and
Site Inspection

and south of Hayward to Fremont on the Fremont Line), the vegetation communities and animal habitats were similar to large portions of surrounding territory.⁹

- 3.6 While songbirds and small rodents are slightly affected by BART operations, the effects do not significantly affect the number or distribution of their populations.

The community types most susceptible to impact from BART construction or operations are songbirds who may be distracted by BART train noise and small mammals and rodents whose nocturnal migration routes along streams may be disturbed by the chain link fence along the BART right-of-way. It was determined that large mammals (deer) and smaller mammals (fox, raccoon, etc.) as well as vegetation communities outside the right-of-way are not sensitive to BART construction and operations. Since the Transbay Tube did not materially alter the bottom configuration of the Bay, it did not affect the character of marine organisms which formed in sediments subsequent to construction.

Communities Affected By BART Construction or Operations

Songbirds: In areas adjacent to the right-of-way, songbirds which utilize sound for communication may be slightly affected by BART train noise (Harvey). However, the literature on noise effects on wildlife is not extensive and this conclusion must therefore be qualified.¹⁰

Small Rodents: Nocturnal migration routes of small rodents to water supplies may be inhibited by the chain link BART fence. The mesh of the fence is not large enough for any but the smallest rodents to penetrate (Harvey). However, the possibility exists for them to burrow under to reach the water.

Communities Not Affected By BART Construction Or Operations

Deer: Coastal deer are numerous in the area east of the Berkeley Hills. The deer are highly adaptive, however, are not particularly migratory, and are not affected by barriers such as the BART protective fence (Gill). Deer are known to have jumped the fence and in one case near Concord a deer was struck by a BART train (Moses).

⁹ Ibid.

¹⁰ Effects of Noise on Wildlife and Other Animals, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C.

Marine Micro-Organisms: The Transbay Tube did not significantly alter the bottom configuration of the Bay. The tube was placed in a trench and later filled in, leaving a slight depression along the Bay floor. The depression was gradually filled by sediments over a period of two to three years (Harvey). Benthic communities therefore became reestablished.

There is little indication of community boundaries among benthic organisms within the Bay (Sustal). It is not likely, therefore, that specialized or rare benthic organisms were removed by BART construction. Possible alteration to the make-up of benthic communities resulting from heat loss from the BART tunnel was investigated. However, due to the depth of sediments above the tunnel and the action of tidal flow, it is not likely that a significant temperature difference from surrounding bottom sediments is occurring (Sustal).

In a ship anchorage area near the Oakland Ship Terminal, a rock shield was placed above the tunnel to protect the tunnel from dragging ship anchors. The protective shield extends above the existing Bay bottom and is kept clear of sediments by tidal flow. Because of this exposed rock, a small micro-ecosystem of different flora and fauna is expected to develop (Harvey). Further investigation will be required to determine the extent of this development.

Vegetation: Vegetation existing adjacent to BART parking lots and stations may be affected by BART lighting. When daylight hours are extended by artificial lighting, normal budding times of vegetation are altered. In vegetated areas adjacent to parking lots budding occurs earlier in the season than usual and thus the premature buds are susceptible to being killed by frost (Harvey).

However, killer frosts are rare in the Bay Area. Therefore, premature budding may take place with little risk of losing plant material (Harvey). In addition, it is difficult to discriminate between the direct effects from BART lighting and the effects attributable to street lighting outside the right-of-way. The effects from BART lighting can only extend for the radius of light thrown by a fixture. This limits the area of potential impact to a normal band of plant material just outside an illuminated parking lot or other BART facility.

- 3.7 No significant impacts will occur to wildlife species from a loss of food or habitat eliminated by BART construction.

Specifically, vegetation species occurring within the right-of-way provide food and shelter for a variety of small birds, rodents, and small mammals. However, these animals are numerous within the Bay Area, and the loss of a few members of each

species will not seriously affect the productivity or continuity of the species in general (Harvey).

This finding is based on the fact that to a large degree these animals are territorial, i.e., they remain within a small area and defend their holdings from other members of their species. Therefore, when existing vegetation was removed from the BART right-of-way, the animals whose territory included the right-of-way had either the whole or part of this territory eliminated. Animals with a significant portion of territory eliminated either had to find a new habitat or did not survive. This impact is not significant, however, because such animals are numerous in the Bay Area.

PLANT OR ANIMAL DIVERSITY

3.8-3.10 - There is great diversity and therefore stability within plant and animal communities affected by BART. This diversity insures that a change introduced by BART which affects one species or community will only have a limited effect on the total communities surrounding the BART right-of-way.

The concept of diversity or the number of individual species within biotic communities comprising a natural system is used to define the resistance of that system to changes from an outside influence. As the diversity within a system increases, the stability of the system increases as well. In this case, as the number of species increases, there is a decreasing change in the total system induced by change affecting only one species.

Within the area encompassed by the BART right-of-way there is a great diversity of plant and animal species, both in number and type as well as in three dimensional arrangement. The majority of these species are located in the urban residential neighborhoods to the east of the Berkeley Hills in the suburban neighborhoods between Walnut Creek and Concord and the oak-chapparral grass communities¹¹ between Orinda and Walnut Creek. The number of species is less diverse in the agricultural area between Hayward and Fremont.

Regionally, it is estimated that there are more than 175 song-birds, 70 or more water birds, 30 (plus or minus) birds of prey, and 50 (plus or minus) marsh or shore birds. There are also 25 reptiles, 14 amphibians, and 50 or more mammalian species.¹² These species are present in the Bay Area but not all may have specifically occupied BART right-of-way territory.

¹¹Wallace, et.al., op. cit., Natural Process Inventory, Map N-11 A "Preferred Habitats of Resident or Nesting Wildlife Species".

¹²Ibid. p. 93.

IMPACTS ON BIOTIC PRODUCTIVITY

3.11-3.12 - The BART system did not significantly reduce regional biotic productivity; however, productivity within the right-of-way was substantially decreased.

Biotic productivity measures the volume or weight of organic material produced per unit area of a site over a specified period of time. A marshland is an example of an ecosystem with high biotic productivity, and a desert represents an ecosystem with low biotic productivity.

Biotic productivity is affected by development or change in land use. When fertile topsoils are replaced by subsoils, gravel, or paving, the productivity of a developed area is reduced. BART construction within the right-of-way substantially decreased biotic productivity in many locations where berms, cut and cover tunnels, or excavations disturbed existing fertile soils. However, where aerial structures were used, there was less disturbance to productivity. The change in productivity resulting from BART construction has also been influenced by the form of existing development near the BART alignment. Where BART alignment is adjacent to previously disturbed surfaces such as transportation corridors or development, productivity has been insignificantly affected.

While BART substantially reduced productivity within the right-of-way, this loss, viewed from the perspective of the East Bay Region served by the BART system, is not significant. Little commercial value was placed on the biotic productivity affected by construction, and it did not serve as wildlife habitats of rare or unique species. The change in productivity resulting from BART construction, therefore, did not affect the general character, dispersion, or quality of major ecosystems within the Bay Area.

NUTRIENT CYCLING

3.13 - BART construction significantly disrupted nutrient cycling where berms, cut and cover tunnels or excavation disturbed the right-of-way. However, BART construction did not significantly affect nutrient cycles in areas outside the right-of-way.

Specifically, nutrient cycling, or the recycling of nitrogen, oxygen, water, and other minerals necessary for plant growth, is one of the fundamental processes occurring in the natural environment. Nutrient cycling affects and is affected by slope soil type, vegetative density, and climate. Nutrients are removed from an area through erosion (i.e., the removal of nutrient

rich surface soils), or through the mixing of surface soils with sterile subsoils or gravel.

Nutrients were generally removed in all areas directly affected by BART construction. When this occurred, rich soil was replaced by sterile material with a greatly diminished capacity to support vegetation. Where landscaping was developed, nutrients were added to the surrounding soil to supplement capacity to support vegetation. However, these nutrients were usually of a lesser quality than those occurring naturally in the alluvial soils of the East Bay and Walnut Creek-Concord area.

Nutrient cycles in areas outside the right-of-way were not found to have been significantly affected by BART construction. In only a few cases erosion occurred resulting in sedimentation outside the right-of-way, and in these cases the sediments were usually contained within local drainage channels.¹³ This slight erosion has a minor effect on nutrient cycling.

¹³See Soils and Geology section of this report, p.54.

CONCLUSIONS

BART construction and operations did not have a significant impact on biotic resources because of the extensive use of aerial structure and route location along existing transportation corridors.

The majority of the BART system is located in urbanized areas along existing transportation corridors, and the included biotic resources are not sensitive to the changes induced by BART construction and operations. Vegetation and wildlife communities removed included a great variety of species common to the Bay Area and not existing as part of a natural system linkage like a stream, valley, indigenous forest or marshland. The removal of randomly placed individual species, therefore, did not significantly affect the growth or the production of species outside the right-of-way. Where indigenous biotic communities were removed for BART construction (e.g., the oak-chapparral-grassland communities between Orinda and Walnut Creek), the impact was not significant because of the relatively limited area of removal and abundance of similar species within the region.

The extensive use of aerial structure also minimized BART's impact on biotic resources. Aerial structure requires a smaller width of taking than an equivalent berm and causes minimum disruption to existing vegetation.

BART's impact on biotic resources was minimized because the BART system was not located in or near sensitive natural environments within the Bay Area.

There are many sensitive environments within the Bay Area where BART could have significantly affected biotic resources. These sensitive environments include marshlands, undisturbed stream valleys, lakes, and unique mountain ecosystems. However, the BART system was not located in any of these sensitive areas. While BART does cross several stream valleys (e.g., Alemand Creek and San Leandro Creek), the stream valleys have been so altered by previous development that these environments are relatively insensitive to the slight additions of runoff or construction disturbances resulting from BART.

BART's removal of existing mature vegetation, primarily large trees, constitutes a significant visual impact. However, this action has little effect on the natural function of biotic communities.

The removal of mature trees and their replacement through landscaping with young plant material, is one of the significant visual impacts resulting from BART construction. The effects are most apparent in station parking lots. This impact is discussed in greater detail in the Environment Project's "Visual Quality" report.

The removal of mature trees did not, however, have a significant impact on the natural function of biotic communities. These functions are more general than effects to individual specimen plants. They are specifically related to linkages within and between natural systems, and are not affected by the maturity of plant material involved.

IMPLICATIONS

BART's impacts on biota were not significant because of the relatively insensitive biotic communities found along the right-of-way. Conversely, the areas where sensitive biotic communities exist are very sparsely populated, and there was no reason to run BART through them. However, these conditions may not exist in other places where mass transit systems are planned, and in such cases great care should be taken in assessing potential effects to biotic resources.

For a majority of its route the BART corridor traversed urbanized, relatively flat terrain. The route generally avoided parks, open space, or fragile marine and mountain ecosystems. This avoidance of sensitive areas can be attributed to the wisdom of BART planners and the reality that such areas generally did not exist along any of the routes where a system like BART would logically be placed.

Such a fortunate relationship between terrain and locational demands, however, may not exist in all cities where a mass transit system will be planned. In eastern cities, for example Washington, D.C., where there are greater elevation changes, higher rainfall, and an interlocking series of stream valley parks, it will be difficult to avoid sensitive areas when planning for transit system extensions. It is imperative, therefore, to undertake environmental analyses for all transit systems to determine the nature and extent of potential impacts to sensitive biotic resources.

DIRECTIONS FOR FURTHER STUDY

Further study on impacts from BART construction and operation on biotic resources will not be required. However, adequate information concerning impacts from alternatives to BART, the NoBART alternatives, has not been developed.

Further investigation should address the biota impacts which would have resulted from the improvement of Route 4 between El Sobrante and Concord. This analysis will define the difference between impacts resulting from BART and impacts which would have been incurred if Route 4 had been improved.

IV. SOILS AND GEOLOGY

DEFINITION AND SCOPE

Soils and geology compose the non-living systems of the natural environment. This category includes all effects of BART operations and construction on the structure of soils and geological formations. Evaluation included impacts on areas within the right-of-way and directly adjacent properties.

The fundamental concern with soils and geological considerations is stability. Impacts occur where BART has induced changes to the right-of-way which have made soil and geologic conditions less stable and therefore more likely to shift. This can cause damage both to BART and surrounding property. The shifting or movement of soil and geologic structures can occur from landslides, seismic activity, or erosion. The magnitude of impacts is measured by the costs both in visual disruption and maintenance activity required to mitigate the effects of soil or geologic movement.

The following factors were considered:

- o Unique geological features
- o Areas with special resource values
- o Slope stability
- o Impermeable soil layers
- o Subsidence
- o Consolidation
- o Weathering
- o Seismic activity

RESEARCH QUESTIONS AND RATIONALE

The research questions for soils and geology were developed through a two stage process. The first phase focused on directly observable effects including the extent to which BART facilities have caused significant erosion and the extent to which erosion control measures have been effective. In the second phase the basis for research questions was expanded to include a broader range of impacts potentially resulting from a project such as BART.

These research questions were further divided into the following two major headings: Measurements of Effects Resulting from BART Construction and Operations on the Surrounding Environment, and Measurements of Effects from the Surrounding Environment on BART Construction or Operations. The following research question categories were included under these headings:

IMPACTS FROM BART POTENTIALLY AFFECTING THE ENVIRONMENT

- o Unique geological features
- o Areas of special resource value
- o Slope stability
- o Impermeable layers

IMPACTS FROM THE ENVIRONMENT POTENTIALLY AFFECTING BART CONSTRUCTION AND OPERATIONS

- o Subsidence
- o Ground consolidation
- o Weathering
- o Seismic activity

IMPACTS ON THE ENVIRONMENT

Impact on Unique Geological Features

The effects from BART construction on unique geologic features are of special importance. Such features include visually prominent rangelines, rock outcroppings, and geologic areas of educational or scientific interest. Impacts in this category can be considered significant when the special feature damaged

or destroyed by BART construction represents the only example of such a feature in the Bay Area or that the feature, while not totally unique, was of special significance because of location or accessibility. The following research question was investigated:

- 4.1 Will any unique geological features be damaged or destroyed by BART construction?

Impact on Areas of Special Resource Value

Areas of special resource value include geologic deposits of potential commercial value. It is important to determine whether such deposits exist and the extent to which the extraction of such deposits may conflict with the efficient operation of BART facilities.

The following research question was investigated:

- 4.2 Are there geologic deposits of potential commercial value which abut or cross the BART right-of-way?

Impact on Slope Stability

The effects from BART construction on slope stability is a fundamental environmental concern. Failures in slope stability by landslides or erosion affect the visual appearance of the BART right-of-way, require control measures in terms of maintenance effort and materials, and in extreme cases can induce displacement of the BART alignment. The following research question was investigated:

- 4.3 Do any potential dangers related to slope failures result from BART construction?

Impact on Impermeable Layers

Impermeable layers within the soil determine the rate and location of ground water flow, and it is therefore important to assess the impacts from BART construction on these geologic formations. The following research question was investigated:

- 4.4 Will BART construction affect impermeable layers causing problems with ground water contamination or drainage?

IMPACT FROM THE ENVIRONMENT

Impact From Subsidence

Land subsidence, generally caused by the excessive pumping of ground water, could seriously affect BART operations. While subsidence usually occurs over a relatively large area, local variations in settlement rate could damage BART structures and alignment. The risk from subsidence, therefore, while not caused directly by BART construction, could be a significant factor in the continued functioning of BART operations. The following research question was investigated:

- 4.5 Is there a risk of major ground subsidence that could affect BART facilities?

Impact from Consolidation

Consolidation, or ground settlement due to excessive bearing loads on soil, could also seriously affect BART operations. Consolidation occurs when the bearing loads on foundations exceed the compression strength of subsoil or underlying bedrock. This problem could affect the delicate alignment of structures on the elevated portion of the BART tracks. Slight deviations in the height of each structure could induce swaying in the BART cars or reduce the assignable maximum speed. The following research question was investigated:

- 4.6 Is there a risk that the alignment of BART structures could be deformed through ground consolidation?

Impact from Accelerated Weathering

Accelerated weathering results from the exposure of previously covered rock or soil escarpments to the effects of air, wind, or water. The increased rate of decomposition caused by chemical reactions within the soil or rock when exposed to these elements can reduce its strength, which in turn can increase the propensity for landsliding and erosion. The following research questions were investigated:

- 4.7 Will BART construction cause an increase in the natural process of rock decomposition?
- 4.8 Will BART facilities be exposed to the results of such increased decomposition?

Impacts from Seismic Activity

Historically California is an area in which earthquakes are relatively common. The constant threat of earthquakes along the

the major (San Andreas and Hayward) faults in the Bay Area is widely acknowledged. It is therefore of importance to evaluate precautions taken during BART construction to minimize the impact from seismic activity in terms of shear zone movement along faults, ground shaking, and liquefaction. The following research question was addressed:

- 4.9 Is there a risk of excessive loss to BART facilities or danger to patrons resulting from seismic activity?

METHODOLOGY

The evaluation of impacts on soils and geology involved three stages: an inductive open-ended search phase, in which information was gathered from many sources; a more directed search phase, in which specific issues identified were analyzed in greater depth; and, finally, a synthesis phase, in which the major findings were evaluated.

OPEN-ENDED SEARCH PHASE

In this first phase a visual survey of the entire BART system was taken. The survey included an aerial reconnaissance, in which oblique photographs were taken of all areas with evidence of possible effects of BART construction on soils or geology. In addition, BART staff members were interviewed to identify measures taken to avoid adverse effects from construction. Finally, officials from each of the cities along the BART route were contacted for their views concerning possible soil and geological impacts. This process uncovered sources of information as well as preliminary indications of potential environmental effects.

DIRECTED SEARCH PHASE

In the second phase these leads were investigated further. Of particular importance were issues concerning slope stability and the measures used by BART staff and consultants to minimize the potential effects from seismic activity. During this phase as well the scope of soils and geological impacts was expanded to include a full range of potential effects.

SYNTHESIS

The final phase involved a synthesis of soils and geological issues identified during the search process. An evaluation was made of impacts to determine their significance using the following criteria:

1. Degree of change to soils and geological formations.
2. Effect of change in terms of increased propensity for landslides and visibility of erosion scars.
3. Potential to affect BART operations.

THE ENVIRONMENT WITHOUT BART

This study's findings are based on the assumption that the following soil and geologic environment would exist in the corridor if BART were not present. This establishes the "baseline" from which BART's net impacts are assessed.

"R" LINE (MAC ARTHUR TO RICHMOND)

The soils and geologic environment along the "R" line would not be significantly different if BART were not present. Along the BART corridor there are no recorded fault zones, mineral extraction sites, or unique geological features which were affected by BART construction. Without BART it is possible, but not likely, that San Pablo Avenue would have been expanded in width and traffic. However, such an expansion would not have affected soil or geologic conditions since major grading would not have been required.

"A" LINE (FRUITVALE TO FREMONT)

Without BART the soils and geologic environment along the "A" line would be relatively unchanged. However, the earth berm built between Hayward and Fremont would not be present, and in a few areas minor cut slope excavations required to maintain the alignment would not have occurred.

"C" LINE (MAC ARTHUR TO CONCORD)

Without BART the corridor between Orinda and Walnut Creek would have been substantially different. An unexpected finding of MTC's study of the history of BART's development¹ is that nine miles of Route 24 between Orinda and Walnut Creek was expanded from six to eight lanes because of BART construction. The California Department of Transportation (CALTRANS) had not planned on enlarging Route 24 beyond its then current grading width. BART lent money to CALTRANS for the matching portion required for inclusion of Route 24 in the interstate system. This resulted in an enlargement of Route 24 from six to eight lanes.

¹McDonald & Smart, Inc., A Generalized NoBART Transportation Alternative, op. cit.

The expansion of Route 24 with BART in the center required extensive excavations along the right-of-way. These excavations and subsequent landslides and erosion which occurred along the right-of-way can generally be attributed to the construction of BART. However, the Orinda soil formations existing along the corridor are historically unstable and some landsliding may have occurred in the area even if BART were not present and Route 24 had not been enlarged.

"M" LINE (GLEN PARK TO DALY CITY)

Without BART the soils conditions along the "M" line would be unchanged. For most of its route above ground BART is elevated along the Route 280 right-of-way side slopes. The design of Route 280 did not originally incorporate nor was substantially altered by BART. Therefore, if BART had not been built, the right-of-way slopes would be unchanged.

OTHER CHANGES

Other changes to the soils and geologic environment which would exist without BART include additional grading from improvements to Route 4 in Contra Costa County.² Also, soil, rock, and other alluvial material would not have been excavated for tunnels in Berkeley, Oakland, and San Francisco.

²Ibid., pg. 77.

FINDINGS

IMPACT ON SPECIAL GEOLOGICAL FEATURES

4.1 - There were no special geological features damaged or destroyed by BART construction.

Documentation and support for this finding reveals that for the majority of its length the BART system traverses relatively flat terrain and therefore caused little disturbance to special geological features. The only major geological feature substantially disturbed by BART construction was the gently sloping hills to the north of Route 24 between Orinda and Walnut Creek. However, these hills are not unique in the Bay Area. The shape of these hills was altered because of BART's right-of-way requirements in combination with the expansion of Route 24 from six to eight lanes. This expansion which resulted in nine miles of major excavation on the north side of Route 24 would not have occurred without BART as described earlier. The existing flow of the ridge line, which had been only slightly deformed by small cut slopes for the six lane Route 24 was substantially altered by cut slopes which in some cases were over 100' high.

In addition, these excavations slightly affect Siesta Valley, a natural area identified by the California Natural Areas Coordinating Council.³ Siesta Valley is located just west of Orinda and is bisected by Route 24 where it emerges from the Caldecott Tunnel. The Valley is used as a study area for U.C. Berkeley students to view its complex geological features. Since the grading for Route 24 exposed certain aspects of this complex geology in greater detail, thus somewhat enhancing its educational value, these effects are not considered to be significant impacts.

IMPACTS ON SPECIAL RESOURCES

It is alleged that BART construction was one among a number of factors which in combination limited the useful life of sand and gravel quarries in the Niles Cone area.

The BART right-of-way required a condemnation of 380 feet through the Niles Cone area just north of Fremont. The impact of this action on sand and gravel quarrying in the area is a matter of

³Siesta Valley Inventory of California Natural Areas, 1975 published by California Natural Areas Coordinating Council, Sonoma, California.

dispute between BART and several quarry operators. The operators contend that they have suffered uncompensated monetary loss because of the location of the right-of-way, and BART is denying the claim. Other factors alleged to be affecting the economy of the quarrying operations are the effect of the water levels maintained by the local water district, restrictive ordinances passed by the City of Fremont, and the state of the local market for sand and gravel. The dispute is currently (early 1976) the subject of legal action.⁴

IMPACT ON SLOPE STABILITY

4.3 - BART construction reduced slope stability in two areas: the excavation sites between Orinda and Walnut Creek, and on earth berms between Hayward and Fremont.

Impact from Erosion and Landslides at Excavation Sites

Severe erosion and landsliding occurred in some locations when major grading was required for BART construction. These impacts resulted from excavation in unstable soil and bedrock formations, particularly in the Orinda formation between Orinda and Walnut Creek (see Figure IV.1).

The Orinda formation is extremely unstable; it is in the process of being uplifted and is composed of a highly expansive clay. These two conditions weaken the internal structure of the soil and cause frequent landslides (Heyes).

Landslides and erosion occurred in seven identifiable sites (Smitten) along the northern side of Route 24 between Orinda and Walnut Creek. The most severely scarred area is located adjacent to the Orinda station where over 4 million cubic yards of unstable soil were removed at the time of a major slide during BART construction. The existing slide is caused by mud flows from a spring near the crest of the cut slope (Moses). The other six sites are relatively minor by comparison.⁵

In addition, there is evidence that unstable soil conditions in this area are causing slight deformations in both the Route 24 pavement and the BART tracks. This deformation is very slight (one to two inches upwards) at present but is being monitored closely both by BART and CALTRANS personnel.

⁴BART vs. Inland Aggregates Company, Inc., et al, SCCAla. 378232.

⁵Aerial photographic inspection.

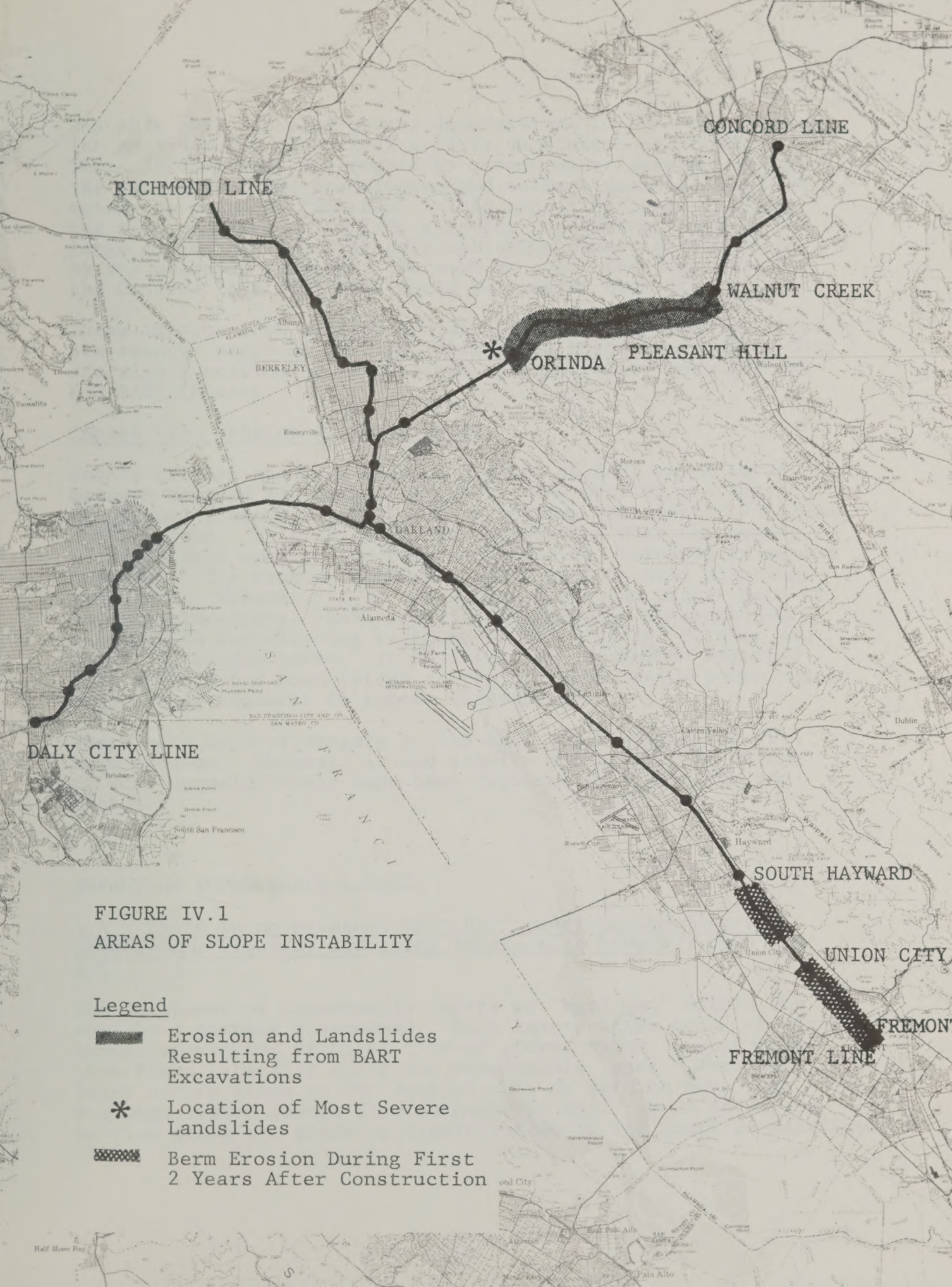


FIGURE IV.1
AREAS OF SLOPE INSTABILITY

Legend

-  Erosion and Landslides Resulting from BART Excavations
-  Location of Most Severe Landslides
-  Berm Erosion During First 2 Years After Construction

Unstable soil has also caused deformations in the BART parking lot and adjacent electrical utility substation at Orinda. These deformations are caused by ground water seeping through the parking lot and transformer pad subbase material and weakening the pavement (Smitten). This condition could increase the time required to replace a faulty transformer because the large cranes required for this operation cannot be supported by the weakened pavement. In such an event the down time for the Concord line (Smitten) would be greater than otherwise.

These impacts from erosion and landsliding at excavation sites are seen by users of BART and associated highway systems. They are also a continuing maintenance responsibility for CALTRANS and BART (Moses).

Impact from Erosion on Earth Berms

Severe erosion occurred along 4.5 miles of BART earth berms between Hayward and Fremont (Moses). The erosion was caused by unusually heavy rainfall during the two year period following construction. This rainfall, in combination with the highly erodable soil used in the berm construction, resulted in severe gullyng. The erosion continued until ground cover planting took hold. However, it is no longer a problem either here or in other locations. BART and city maintenance personnel were responsible for clearing sediment-filled drainage ditches and repairing eroded berms. In addition, one spokesman asserted that Hayward had been forced to replace storm water pumps ruined from excess sediment in runoff (Lindsburg).

There were no real dangers to the BART track associated with berm erosion. However, it did require maintenance in excess of what normally would have been required to repair the condition.

IMPACT ON IMPERMEABLE LAYERS

4.4 - There is no evidence that BART construction diverted ground water flows by affecting impermeable layers within the soil.

The existence of impermeable layers or "hard pan" within the soil is a complex phenomenon. Such layers often occur at various levels preventing vertical flow of ground water. Ground water then flows laterally along the impermeable layer. When this layer occurs close to the surface, soil is said to have poor drainage; water cannot flow through the soil, so it is forced to flow along the grade or remain ponded if the grade is relatively flat.

While data concerning the depth to impermeable layers along the BART right-of-way was not available, Public Works officials in cities along the BART route did not indicate that shallow ponds had occurred along berm embankments or that vegetation was dying in any areas near the right-of-way. This suggests that either impermeable layers were not encountered during construction, or if they were, BART drainage facilities were adequate.

IMPACT FROM SUBSIDENCE

4.5 - Subsidence is not significant in the area served by the BART system, and measures are presently being taken to prevent subsidence from occurring in the future.

Historically, ground subsidence has not been a problem in the Bay Area north of Fremont. However, south of Fremont and in many parts of Santa Clara County subsidence has occurred from excessive pumping of ground water. Ground water pumping between Hayward and Fremont has led to a lowering of the ground water table in the past, but this did not result in measurable subsidence, and the condition is now stabilized through ground water recharging in the Niles Cone area (Killingstead). BART appears to have had no effect on this problem, nor has BART experienced any effects.

IMPACT FROM CONSOLIDATION

4.6 - No significant effects to BART structures or alignment resulting from differential settlement have been observed.

Supporting documentation for this finding reveals that in the initial phase of BART design and planning the problem of differential settlement was identified as a potentially critical one. This concern led to design decisions which would minimize disruption to BART operations through the differential settlement of structures. These decisions included the use of a simple span system for the elevated structure in which the beam ends are resting directly on support columns; the use of pilings for all support columns; and the use of a granular material as a base for the Transbay Tunnel.

Simple Spans

Simple spans were used for the construction of all BART structures to allow the maximum flexibility within the supports. If differential settlement should occur it would be easy to shim the tracks to maintain the alignment (Moore).

Pilings

Pilings were used for all elevated structures to minimize problems with differential settlement. The depth of piles and the number used were designed for local soil conditions (Moore).

Granular Base Material

A granular base material was used for the Transbay Tube to spread the Tube structure weight evenly over the soft Bay bottom mud. The use of this material minimized the effects from differential settlement (Moore).

IMPACT FROM ACCELERATED WEATHERING

4.7 - The exposure of Orinda formation soils along the northern side of Route 24 accelerated the weathering process, thereby weakening the existing unstable structure of these soils and increasing the potential for additional landslides and erosion.

Accelerated weathering occurs when soil or bedrock is exposed directly to the effects from air, wind, and water. In the case of cut slopes along Highway 24, the very unstable Orinda soils were exposed to these elements. This exposure produces chemical reactions that weaken the soils and increase their propensity to slide and erode. Such slides, if they are severe enough, could damage Highway 24 and the included BART facilities (Heyes). However, because of the complex interrelationships between weathering, soil structure, groundwater, and other factors in determining the occurrence and severity of landslides it has not been possible, within the scope of this study, to determine the extent of the danger from major slides on Highway 24 that can be directly related to accelerated weathering of Orinda formation soils.

IMPACT FROM SEISMIC ACTIVITY

4.8 - Since there is a widely acknowledged potential for major seismic activity in the Bay Area, BART design included several unique features to minimize adverse effects from shear movement along faults, ground shaking, and liquefaction.

The BART system crosses the Hayward fault in the Berkeley Hills and along the rest of its length the system will be affected by ground movement from earthquakes. It was of great concern, therefore, on the part of BART engineers, to minimize the effects from seismic activity on BART facilities. The three character-

istics of seismic movement requiring specialized design solutions included shear zone movement along faults, ground shaking and liquefaction.

Shear Zone Movement Along Faults

BART intersects the Hayward fault at the western entrance to the Berkeley Hills tunnel. This is the only location within the BART system where a major active fault zone is crossed. The following measures were used to minimize the effects of shear zone movements (Moses):

Tunnel Section Tying

At the entrance to the Berkeley Hills tunnel the Hayward fault is actually a 1,000 foot zone of pulverized bedrock. Through this section the BART tunnel was constructed from concrete ring sections 2-1/2 feet wide. If movement should occur along the fault in any direction, these sections can easily be replaced during one three hour work shift so that normal operations will not be disrupted. Many smaller non-active fault systems were also discovered during construction of the Berkeley Hills tunnel and in each case similar ring sections were installed. In all areas in which the ring sections were installed, the tunnel diameter is wider than normal to allow greater flexibility in adjusting tunnel sections and track should fault movement occur (Moses).

Tunnel Separation

The Berkeley Hills tunnel is actually composed of two separate tunnels spread apart by as much as 1,000 feet in the center. The purpose of this separation is to minimize damage to both tunnels should movement along the fault occur. At the portals to each tunnel where they come together, crossover tracks have been installed so if one tunnel is damaged trains from both directions can use the other tunnel (Moses).

Cross Tunnels

The two main trackway tunnels are interconnected by passageways every 1,000 feet along the four mile route. These passageways will allow maintenance personnel access to both tunnels from any location and serve as alternate exitways should a BART train be located in one tunnel when earthquake damage occurs (Moses).

Fault Deflection Meters

A fault deflection meter has been installed to detect the slightest movement along the Hayward fault. The meter is sensitive to any movements along the fault, including those which would not be visible (Moses).

Ground Shaking

Ground shaking will affect all parts of the BART system should major seismic activity occur in the Bay Area. To counter this effect all BART structures were designed with a simple span construction to allow maximum flexibility during any such episodes.

With simple span construction the span beams are not integrally tied to the pier, but are connected to the pier cap by a six inch diameter pin. The span beams are not continuous over the pier, and therefore will not be adversely affected within limits by lateral or vertical displacement (Moore).

Liquefaction

Liquefaction is a phenomenon which occurs in some very fine soils during seismic activity. During liquefaction soils which are normally firm become "liquid" causing structures to shift out of plumb. The only areas within the BART system with soils subject to liquefaction are the Oakland portal and bed of the Transbay Tube. A granular material was used as a base for the Transbay Tube to mitigate possible effects from liquefaction (Moore).

CONCLUSIONS

BART construction removed soils and geologic resources where BART and related freeway construction traversed steep terrain, particularly on the north side of Route 24 between Orinda and Walnut Creek. However, the effects of grading, landslides, and erosion resulting from this excavation were primarily visual and did not directly affect BART operations or surrounding residences.

The extensive excavations required to expand Route 24 from six to eight lanes altered existing landforms, caused landslides and erosion in areas with unstable soils. While some visual impacts were created by these landslides, the excavating did not have significant effects on BART operations, freeway capacity, or residents in surrounding communities.

The one major impact, a massive landslide which occurred during early stages of construction on Route 24 in 1965, was mitigated by alterations in freeway design and excavation of loose material. Since 1965 no major landslide has directly affected the freeway or BART operations.

Where BART traversed relatively flat terrain there were no significant impacts on soils or geologic resources.

BART had little effect on soils or geologic resources in areas of flat terrain because of the extensive use of aerial structures and the limited requirements for grading. Since most of the system is located in existing urban corridors with little elevation change, no special geologic features, and limited areas where slope stability is a potential problem, there were negligible impacts on soils and geologic resources.

Design features were incorporated into the BART system to minimize impacts to BART from ground subsidence, consolidation, accelerated weathering of cut slopes, and seismic activity.

Standard engineering practices were employed to ensure BART facilities can absorb limited amounts of ground movement. To date these measures have been effective. However seismic activity or other ground movement which exceeds these built-in limits will cause severe damage and disruption to the BART system.

IMPLICATIONS

BART's impacts on soils and geologic resources were not significant because special geologic features did not exist along the selected right-of-way and appropriate engineering practices were employed to maintain stable slopes and system flexibility during ground movement.

The primary effects of a major engineering project like BART on soils and geologic features are visual changes resulting from massive excavation and grading. These impacts are experienced as changes to the natural shape of the hillsides, but the effects are softened over time by the growth of ground cover and other plant material.

Other effects include BART-related changes to landforms which may be potentially damaging to surrounding land uses. Adverse effects from these conditions, for example landslides, ground consolidation, subsidence, etc., can be minimized through appropriate engineering practices. To date the practices adopted by BART planners have prevented significant impacts both to soils and geologic resources from BART construction and from soils and geologic conditions to the BART system.

In other cities where mass transit systems will be planned, the geologic conditions may be different from those in the Bay Area. In these cases, other engineering practices will be required to minimize impacts from soils and geologic resources.

DIRECTIONS FOR FURTHER STUDY

Directions for further study include an analysis of alternatives to BART as defined under the NoBART alternative and an investigation of indirect soils and geologic impacts from development induced by BART construction.

Further investigation should address the soils and geologic impacts which would have resulted from the improvement of Route 4 between El Sobrante and Concord. This analysis would define the difference between impacts resulting from BART and impacts which would have been incurred if Route 4 had not been developed.

One of the most significant directions for further study is the indirect impacts from growth induced by BART construction. These effects are outside the scope of this report and yet may well be of much greater significance than the more direct effects previously identified.

DEFINITION AND SCOPE

Drainage and water systems make up the linkage between the living and non-living components of the natural environment.

Water system impacts on BART and resulting from BART construction are measured by observed changes in local and regional surface and ground water drainage patterns. Potential types of impact include those on surface drainage, aquifer yields, ground water recharge, water quality, storm water flooding and sedimentation. In addition, the impacts to BART from impoundment leakage and failure were also investigated. This set of impacts was selected for its comprehensiveness as well as its compatibility with impact assessment procedures now being developed for the U.S. Department of Housing and Urban Development.

The focus of this assessment is on the effects of BART construction on local drainage patterns, particularly drainage near parking lots. The assessment has included determination of the degree to which BART has either improved local drainage systems or created a need for improving local drainage resulting from BART construction or BART-induced development. Local drainage systems around parking lots were studied intensively because they represent the area where BART's potential impact on drainage is the greatest. The regional implications of BART in changing drainage flow and ground water patterns were addressed in lesser detail.

RESEARCH QUESTIONS AND RATIONALE

IMPACT ON HYDROLOGIC BALANCE

The hydrologic balance represents the system of water transfer from the entry of water into the ground as rain to its return to either the ocean or the atmosphere. This balance can be viewed both from a regional and a local perspective. The regional hydrologic balance is determined by the summation of local conditions. Its primary determinants include major watersheds, major rainfall patterns, and dominant topographical-geologic conditions. The local hydrologic balance is determined by the combinations of these factors found in a given locale. It is of concern, therefore, to determine whether any aspect of BART construction has affected elements of the hydrologic balance. The following research issues were investigated:

- o Impacts on Surface Drainage
- o Impacts on Aquifer Yield
- o Impacts on Ground Water Recharge
- o Impacts on Water Quality
- o Impacts on Storm Water Flooding
- o Impacts on Sedimentation
- o Impacts from Impoundment Leakage or Failure

IMPACTS ON SURFACE DRAINAGE

The effects of BART construction on the direction, duration, and intensity of surface water flows have widespread impacts on surrounding communities. These effects are experienced directly from the construction of parking lots and other facilities, and indirectly from residential growth spurred by the increased accessibility BART has introduced. The important issues, therefore, are the adequacy with which BART has accommodated storm water drainage from parking lots, the effects of BART drainage in city storm water systems, and the potential for contamination of local water bodies by runoff from BART facilities. The following research question was addressed:

- 5.1 To what extent have BART facilities, particularly parking lots, caused increases in local storm water runoff and contamination? Has this led to any downstream effects?

IMPACTS ON AQUIFER YIELD

Aquifers, or underground lenses of gravel and sand through which water flows are essential to the maintenance of ground water levels and water supply for domestic and industrial uses. The disruption of aquifer through BART construction could have serious consequences to water users over a wide area. The following research question was addressed:

- 5.2 Will the physical characteristics of aquifers be changed as a result of BART construction thus affecting aquifer yields?

IMPACTS ON GROUNDWATER RECHARGE

Ground water recharge areas are essential to the maintenance and quality of water supplies. Paving, grading, or other changes to ground water recharge areas can deplete ground water supplies. It is of concern, therefore, to determine whether any aspect of BART construction has affected primary ground water recharge areas or watersheds which recharge public water bodies. The following research question was addressed:

- 5.3 Will BART paving or construction over recharge areas prevent water infiltration from the water surface to replenish groundwater or reservoir supplies?

IMPACTS ON WATER QUALITY

Runoff from BART parking lots containing grease and other chemicals could damage water quality in nearby drainage systems or water bodies. This requires determination of the intermediate and ultimate discharge points for BART parking lot runoff in local water bodies, stream systems, or San Francisco Bay. Where parking lot runoff is deposited directly in a local water body or stream system there is a danger that contaminants including petroleum products and other chemicals may adversely affect aquatic or streamside habitats. The following research question was addressed:

- 5.4 Will contaminants in BART runoff adversely affect public water supplies, aquatic habitats, or streamside habitats at intermediate and ultimate point of discharge?

IMPACTS ON STORM WATER FLOODING

Storm water flooding caused by inadequate drainage facilities is a problem that may result in damage to properties surrounding BART stations or along storm sewer systems. It is important, therefore, to determine the extent of such flooding at BART facilities or the measures employed by BART to minimize its occurrence. The following research question was addressed:

- 5.5 To what degree have BART facilities been a risk to life and property due to flooding?

IMPACTS ON SEDIMENTATION

Sedimentation from BART construction may affect local water bodies, wildlife habitats, stream quality, and surface drainage channels. It is important to determine the extent and locations of excessive sedimentation due to BART construction activities. The following research question was addressed:

- 5.6 To what extent did BART construction in any area result in major sediment influx into adjacent water bodies?

IMPACTS FROM IMPOUNDMENT LEAKAGE OR FAILURE

Impoundment leakage, or flooding, which results from the failure of a reservoir dam during seismic activity is a concern that may affect the BART system. This problem will exist if the BART right-of-way lies in the path of flood waters caused by the failure of a major dam. The following research question was addressed:

- 5.7 Is any part of the BART right-of-way located downstream from an artificial impoundment?

METHODOLOGY

The methodology used in assessing impacts on drainage and water systems from BART construction included an inductive open search phase in which many individuals knowledgeable about the effects of BART were contacted and issues were identified for further study, a more refined search phase in which the potential drainage problems identified initially were studied in greater detail, and finally an evaluation phase in which this information was synthesized and conclusions drawn.

INDUCTIVE PHASE

During the first part of the study a search was conducted of possible sources of information concerning drainage impacts. This search focused primarily on BART officials knowledgeable about measures taken concerning drainage problems and local city officials. The purpose of this phase was to refine the scope of the study and uncover specific issues requiring further investigation.

REFINED SEARCH PHASE

The inductive phase uncovered several issues (or impact sub-categories) of potential significance. In the following phase, care was taken to verify findings by using more than one method of investigation. This triangulation on issues significantly increased confidence in particular conclusions.

FINAL SYNTHESIS

The final phase involved a synthesis of soils and geologic issues identified during the search process. An evaluation was made of impacts to determine their significance using the following criteria:

1. The degree to which storm water runoff from station and parking lots had been adequately accommodated.
2. The degree to which BART runoff could degrade water quality in surrounding streams or ponds.

3. The degree to which BART construction affected ground water supplies, groundwater recharge, or other elements of the local hydrologic balance.

THE ENVIRONMENT WITHOUT BART

It is assumed for the purposes of this study that the following water system/drainage conditions would exist along the right-of-way if BART had not been built. These "NoBART" conditions form the baseline from which BART's impacts are assessed.

"R" LINE (MAC ARTHUR TO RICHMOND)

Drainage conditions along the "R" line with or without BART would be similar. The cities of Richmond, El Cerrito, Albany, and Berkeley had generally adequate storm drainage systems before BART construction. In addition, since these cities are fully developed and recent growth has been very low, these systems would be adequate with or without BART. However, spokesmen for Richmond and El Cerrito (Fuller, Munoz) asserted that their areas would not have experienced the slight flooding problems (to be discussed in a later section) which have resulted from BART construction.

"A" LINE (FRUITVALE TO FREMONT)

With the exception of San Leandro, drainage conditions along the "A" line with or without BART would be similar. In San Leandro, BART assisted the city in replacing a storm sewer system which could not accommodate BART runoff (Alexander). The storm sewer capacity had already been exceeded in Union City at the time of BART construction, but funds were obtained from the Alameda County Flood Control District to increase the system's capacity (Moses). The system evidently would have needed to be improved regardless of the influence of BART. Finally, without BART, storm water runoff from the Fremont BART station parking lot would not be draining into the adjacent natural Tule Pond. However, the Tule Pond historically has served as a storm water holding basin for runoff from the surrounding area. Along the Fremont line no other water system components were affected by BART construction.

"C" LINE (MAC ARTHUR TO CONCORD)

Along the "C" line drainage conditions would be generally similar with or without BART. One exception is in Walnut Creek,

where BART financed a 108" storm sewer line to service its Walnut Creek station and the surrounding area (Boners). However, the population growth which would likely have occurred in Walnut Creek even without BART would probably have required the eventual installation of a similar storm sewer system. Storm drainage systems in the cities of Concord, Pleasant Hill, Lafayette, and Orinda would not be significantly affected by the absence of BART (Boners). Local drainage, ground water recharge, the direction of groundwater flow, the water table, and other elements comprising local hydrologic balance along Route 24 were not significantly altered by the expansion of Route 24 from six to eight lanes.

"M" LINE (GLEN PARK TO DALY CITY)

Without BART, drainage conditions along the "M" line would be unchanged. For most of its length the "M" line is underground and therefore would not have affected surface drainage patterns. Where it emerges from the ground just south of the Glen Park station the line is elevated on the Route 280 right-of-way which would have existed without BART. Balboa Park and Daly City station were constructed in previously urbanized areas with adequate drainage capacity to absorb parking lot runoff.

OTHER CHANGES

Without BART there is a substantial possibility that Route 4 between El Sobrante and Concord would have been improved. This improvement, however, would not have resulted in significant changes to drainage patterns along the predominantly rural right-of-way.

FINDINGS

IMPACT ON SURFACE DRAINAGE

5.1 - Where city storm sewers had adequate capacity to absorb runoff from BART facilities, BART typically did not undertake their expansion or improvement. However, in several cases when existing storm sewer systems did not have capacity for BART runoff, BART upgraded portions of the system to expand its capacity beyond its own station and parking lot requirements. This allowed the accommodation of some drainage effects from possible BART-induced urban development.

According to public works directors in affected cities, there were no cases in which BART did not provide adequately for runoff from its facilities. In some cases BART tied directly into existing city storm sewer systems; in other cases where existing storm sewers did not have the capacity required for BART drainage, BART participated in upgrading the storm sewer system.

A central issue which emerged during negotiations with cities for storm sewer service was the problem of drainage requirements from BART-induced growth. While BART did not follow a consistent policy on this issue, its response appeared to be generally determined by the excess capacity available in city storm sewer systems. If additional capacity was available, BART did not provide excess capacity for effects of induced urban growth. In some cases where the city did not have additional capacity, BART upgraded the entire system in excess of its own specific requirements.

BART upgraded storm sewer systems in Walnut Creek and San Leandro (Moses). In both of these cases BART construction served as a catalyst, focusing attention on a pre-existing drainage problem and participating in its solution. In all other cities there was adequate existing capacity to absorb storm water from BART facilities.

IMPACTS ON AQUIFER YIELDS

5.2 - BART construction did not have a significant effect on aquifer yields along the right-of-way.

Specifically, the construction of the BART system did not involve the scale of grading required to seriously affect the structure of local aquifers. Major grading occurred in

only one area, between Orinda and Walnut Creek, and significant aquifers were not exposed (Smitten).

IMPACTS ON GROUND WATER RECHARGE

5.3 - The BART right-of-way did not traverse areas considered to have a high groundwater recharge value for water supply.

This finding responds to the research question cited earlier: Will BART paving or construction over recharge areas prevent water infiltration to replenish groundwater or reservoir supplies? BART construction did not occur in primary recharge zones as indicated by the MTC/Environmental Impact Assessment Procedure Surface Hydrology Map N-6.¹ The majority of the right-of-way is located in areas where drainage is not used for water supply (see Figure V.1). In addition the area covered by BART parking lots represents a very small percentage of terrain available within the region for groundwater recharge. Even if the paved areas were located in prime recharge areas, their effect on groundwater availability would be very limited.

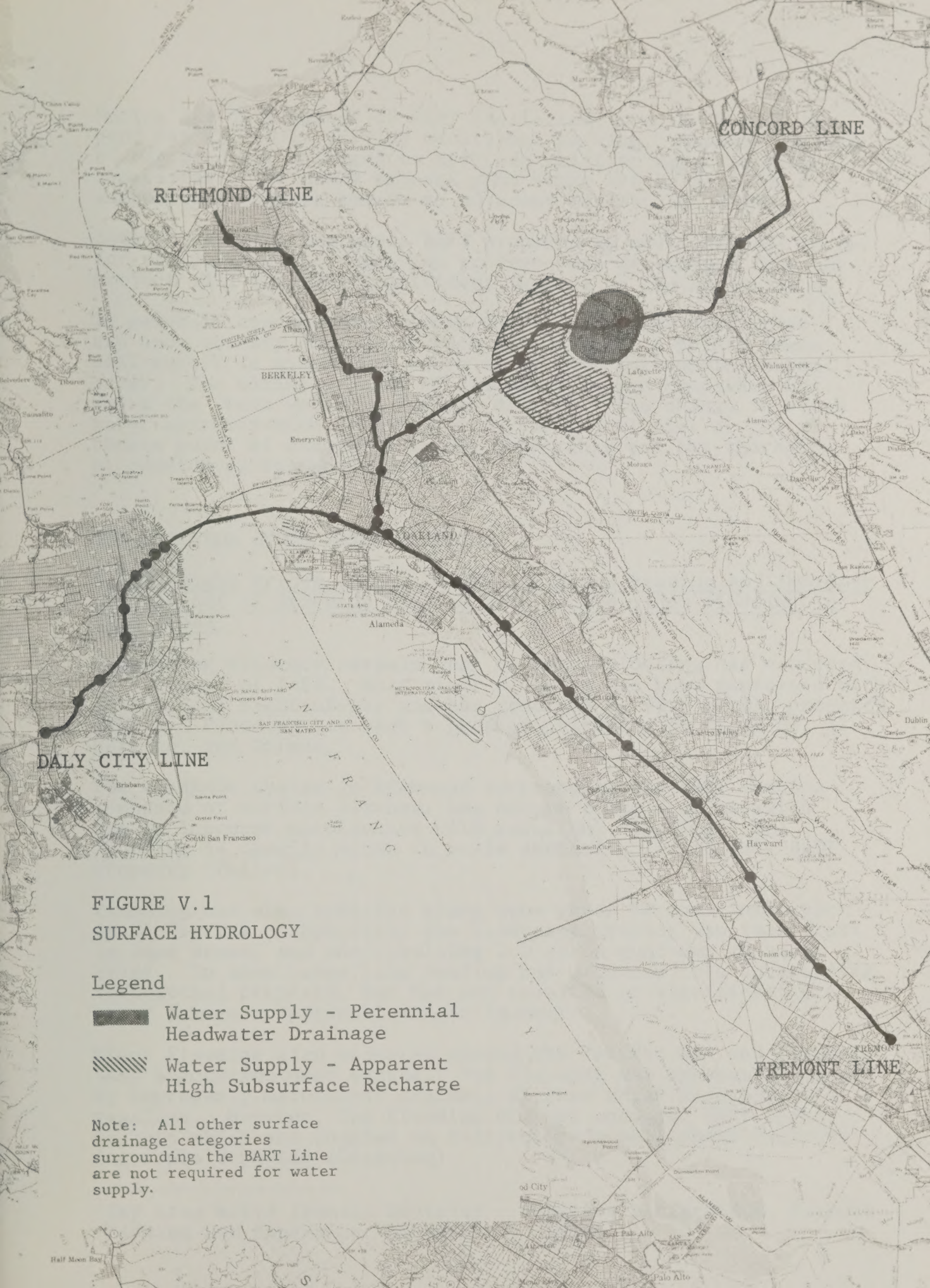
IMPACTS ON WATER QUALITY

5.4 - Runoff from most BART facilities, with the exception of the Tule Pond at the Fremont station, drains into citywide storm drain systems before reaching a point of discharge. Any damage to aquatic or streamside habitats resulting from contaminants in this storm water can only imperceptibly be attributed to runoff from BART facilities.

Documentation in support of this finding shows that the only contained water body directly affected by runoff from BART facilities is the Tule Pond adjacent to the Fremont station. Runoff containing petroleum products and other chemicals may directly affect aquatic life in the pond.

The Tule Pond, which may have been created by seismic activity along the Hayward fault, is currently utilized as a flood storage reservoir for the Alameda Flood Control and Water Conservation District (Johnson). Much of its drainage area is either in agricultural or urban uses. Runoff from these areas supplies nutrients to the pond resulting in accelerated eutrophication. However, this growth usually dies out annually during the summer months.

¹Wallace, et.al., op.cit., Natural Process Inventory, Map N-6 Surface Hydrology.



RICHMOND LINE

CONCORD LINE

BERKELEY

OAKLAND

DALY CITY LINE

FREMONT LINE

FIGURE V.1
SURFACE HYDROLOGY

Legend

-  Water Supply - Perennial Headwater Drainage
-  Water Supply - Apparent High Subsurface Recharge

Note: All other surface drainage categories surrounding the BART Line are not required for water supply.

During the development of BART facilities, one section of the pond was filled to provide additional parking. Another section of the pond was enlarged to maintain existing water-holding capacities. The newly exposed pond banks are to be landscaped with species common to adjacent undisturbed banks.

Before modifying the pond, BART prepared an environmental study for the parking lot expansion project, and determined that the project will not have significant impacts on the environment.²

In general, contaminants within runoff from BART facilities are very quickly diluted at secondary discharge points where BART runoff is mixed with storm water from surrounding urban areas. The ultimate point of discharge is San Francisco Bay where the storm water is further diluted. The change in storm water contamination resulting from BART facilities at the ultimate point of discharge is not measurable and can therefore be considered insignificant.

IMPACTS FROM STORM WATER FLOODING

5.5 - Slight errors in final BART landscape grading and improper maintenance of drainage ditches have caused minor flooding in some areas.

Supporting evidence reveals that no major flooding has occurred as a result of BART. Most minor flooding has been contained within the BART right-of-way and has resulted in very little property damage. Flooding has been a problem primarily in Richmond, El Cerrito, and Orinda.

The drainage system in Richmond surrounding the BART station composed of surface ditches, has become clogged on occasion due to improper maintenance with resultant flooding. The flooding is usually minor in scale and has affected only BART property (Fuller).

Flooding has also occurred along some parts of the linear park in El Cerrito. Apparently the landscape grading was inaccurate in some areas, and the resulting low spots pond during heavy rains. In some cases, the ponding has extended into surrounding residential property, but has not resulted in significant property damage or personal danger (Munoz).

Minor flooding also occurred around the Pacific Gas and Electric BART substation near Orinda. The flooding was apparently caused by improperly maintained drainage ditches which have now been repaired. However, the flooding did not endanger BART transformers which are located on concrete pads well above surrounding asphalt paving (Gazarian).

²Bay Area Rapid Transit District - Negative Declaration; Fremont Parking Lot Expansion, December 23, 1974.

IMPACTS FROM SEDIMENTATION

5.6 - BART construction did not result in significant sedimentation in local stream channels or water bodies.

After an extensive investigation using aerial photographs of BART stations, site inspection, and discussions with both BART and city officials, there did not appear to be areas of significant sedimentation resulting from BART construction or storm water runoff. The only major area of sedimentation which did not result in significant impacts occurred along the track embankments between Hayward and Fremont. In this case, unusually heavy rains during the two years following construction caused erosion from the berms and subsequent sedimentation in surrounding drainage ditches (Moses).

It is alleged by one city official in Hayward that storm water pumps used to transfer BART runoff to the city storm sewer system had to be replaced because of excessive sediments in the runoff (Lindburg). However, this problem only continued until ground cover planting became established on the berms. Since that time there have been no significant problems with sedimentation.

IMPACTS FROM IMPOUNDMENT LEAKAGE OR FAILURE

5.7 - A major washout of the BART tracks could occur if upstream dams on San Leandro Creek, San Lorenzo Creek, Ward Creek or Alameda Creek are damaged during an earthquake.

This major finding responds to the research question cited earlier: Is any part of the BART right-of-way located downstream from an artificial impoundment? The state Office for Emergency Services acting with authorization under Senate Bill 896 is preparing inundation maps of flood zones from the failure of upstream dams during an earthquake (see Figure V.2). These streams, San Leandro Creek, San Lorenzo Creek, and Alameda Creek contain permanent artificial impoundments of sufficient size to damage the BART alignment should there be a failure of the dams (Moore). A fourth, Ward Creek, contains a flood control dam which does not retain a permanent water body but is occasionally filled during the winter months.

The likelihood of an earthquake of sufficient power to damage these structures is problematical. If such an earthquake were to occur, other damages caused to the BART system may reduce its usefulness without major washouts along these stream systems. However, this problem has been identified by the state and has been included as a potential impact for the BART system.

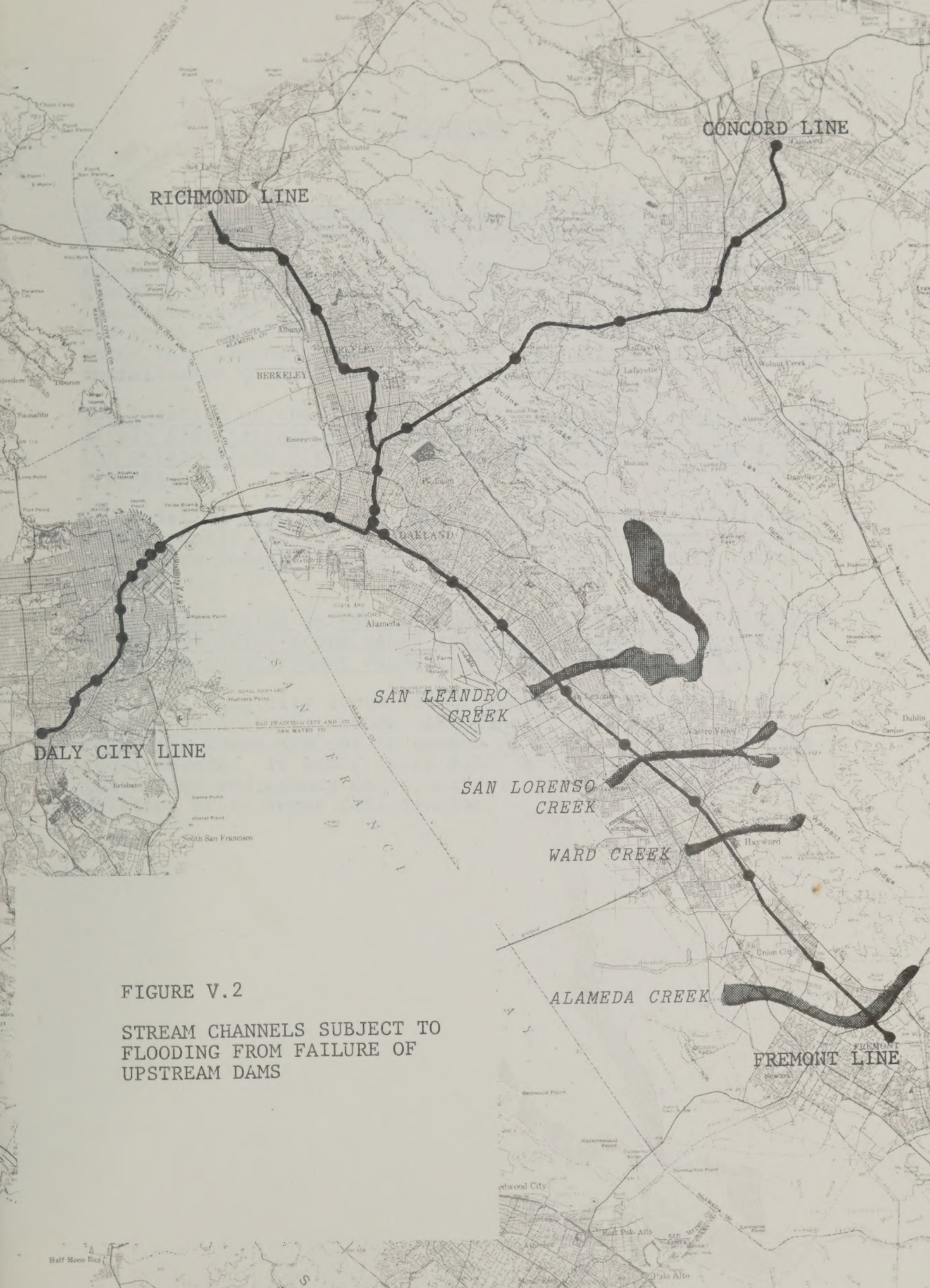


FIGURE V.2

STREAM CHANNELS SUBJECT TO
FLOODING FROM FAILURE OF
UPSTREAM DAMS

CONCLUSIONS

There was no evidence uncovered in this study of significant drainage problems resulting from BART construction.

Standard engineering practices were employed during design and planning for the BART system to ensure that adequate drainage facilities were provided for all BART stations, parking lots, and track rights-of-way. Where minor drainage problems did occur they can be traced to either poor maintenance or improper installation of otherwise appropriate facilities.

The location of the BART system for most of its length on relatively flat terrain and along existing urban corridors minimized the potential to disrupt major ground or surface water drainage systems.

The existing drainage systems affected by BART were already significantly altered by previous urban development and, therefore, were insensitive to slight increases in runoff induced by BART.

BART construction served as both a contributor and a catalyst to upgrade major storm sewer systems in communities, where there was insufficient capacity to absorb BART runoff.

Where existing city storm sewer systems did not supply sufficient capacity to absorb BART runoff, BART contributed to upgrading these systems in excess of their specific drainage requirements. In other cases BART served as a catalyst to get cities and county water control districts to solve long existing storm sewer deficiencies.

IMPLICATIONS

BART's impacts on drainage systems were not significant because of the slight elevation changes occurring along most of the right-of-way and because standard engineering practices were employed to accommodate BART runoff.

For a majority of its route the BART corridor traversed unbanked relatively flat terrain. In such areas storm sewer drainage systems were sufficiently developed to accommodate BART runoff. However, in other cities where a mass transit system may be developed this may not be the case.

In the few cases where existing storm sewer systems did not have sufficient available capacity for BART runoff, BART participated in improving the entire system. By doing so, BART agreed to contribute drainage facilities for future urban growth stimulated by the increased accessibility provided by the BART system. While this study has not been directly concerned with these effects, the precedent set by BART to provide drainage for induced growth is of significance in other cities where mass transit systems are to be planned.

DIRECTIONS FOR FURTHER STUDY

Further study of direct impacts from BART construction on drainage systems will not be required. However, adequate information concerning drainage impacts from alternatives to BART, the NoBART alternatives, and the indirect land use impacts on drainage systems from growth induced by BART has not been developed.

Further investigation should address the drainage impacts which would have resulted from the improvement of Route 4 between El Sobrante and Concord. This analysis would define the difference between impacts resulting from BART and the impacts which would have occurred if these other systems had been developed. In addition, the indirect impacts on drainage systems from growth induced by BART requires investigation.

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BIBLIOGRAPHY

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APPENDIX A

The first appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

APPENDIX B

The second appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

APPENDIX C

The third appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

The fourth appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

The fifth appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

APPENDIX D

The sixth appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

APPENDIX E

The seventh appendix contains a list of the names of the persons who were interviewed for the study. The names are listed in alphabetical order of their last names. The names are listed in the following order: [illegible]

APPENDIX A: VEGETATION TYPES* AFFECTED BY BART

RESIDENTIAL/INSTITUTIONAL

Residential-institutional vegetation includes a mixture of exotic and native varieties of trees, shrubs, and ground covers. This is the vegetation commonly used for residential, commercial, and public landscaping in the cities affected by the BART right-of-way.

URBAN GRASSLAND

Urban weedlots represent the major vegetation type in this category. Other urban grasslands are represented by golf courses and park lawns.

GRASSLAND

The composition of the study area's extensive grassland has radically changed in the past century mostly due to overgrazing. Where once perennial bunch grasses (Stipa) grew, non-native annual oats (Avena fatua), bromes (Bromus), and annual blue-grasses (Poa annua) have taken over.

During the dry period in late summer and autumn, these grasslands are highly combustible. Both surface and rooted material dies completely, thereby providing more fuel for the fire. Probably all grasslands in California are grazed at some time or another but at differing intensities. Not all the grasses are of uniform grazing quality, and some annuals such as goat grass (Aegilops) can be harmful to livestock.

Wild flowers such as blue-eyed grass (Sisyrinchium bellum) and Mariposa lilies (Calochortus) occur where grazing is sporadic or less intensive. Coyote bush flourishes on those grasslands where fire and grazing have been absent for some time.

WOODLAND

The woodland includes blue oaks (Quercus douglasii) and Digger pine (Pinus sabiniana) on the driest sites, and varying mixtures

* Descriptions abstracted from Wallace, et.al., op.cit., Natural Process Inventory, pp. 81-85.

of madrone (Arbutus menziesii), black oak (Q. kelloggii), California buckeye (Aesculus californica), valley oak (Q. lobata), live oak (Q. agrifolia), tanbark (Lithocarpus densiflora) and others on more mesic sites, near streams and on west and north facing slopes. Where grass savannahs predominate, scattered thinly with Digger pine and blue oaks, low moisture levels are indicated. With increased moisture the woodlands become dense and larger species such as valley and live oak are the major components of the woodland.

STREAMSIDE

Common Riparian species include sycamore (Plantanus racemosa), big-leaved maple (Acer macrophyllum), and alder (Alnus rhombifolia). Willows (Salix) and creek dogwood (Cornus) become frequent with increasing elevation. Numerous exotic species are also found along area streams.

AGRICULTURAL

The region does not contain extensive agricultural areas, since urbanization has eliminated most sites. Row crop species and old orchards represent the major agricultural land uses.

APPENDIX B: PERSONS INTERVIEWED DURING STUDY

1. John Alexander, Assistant Director of Public Works, City of San Leandro.
2. Lyn Boners, Department of Public Works, City of Union City.
3. Herbert Epstein, Chief Planner, City of Fremont.
4. Robert Fuller, Street Superintendent, City of Richmond.
5. Robert Gazarian, Maintenance and Substation Division, Pacific Gas & Electric Company.
6. Robert Gill, District Biologist, Grissly Island Wildlife Area.
7. Dr. Thomas Harvey, Professor of Biology, San Jose State University.
8. Miriam Hawley, BIP Liaison Coordinator, BART staff.
9. David G. Heyes, Engineering Geologist, California Department of Transportation (CALTRANS).
10. T. Johnson, Alameda Flood Control District.
11. Jerry Killingstead, Water Resource Specialist, Alameda County Flood Control District.
12. John Lindsburg, Department of Public Works, City of Hayward.
13. Donald F. Moore, Tudor Engineering Company.
14. Harry M. Moses, Governmental Relations Engineer, BART.
15. John Moore, Assistant Director, Office of Emergency Services, County of Alameda.
16. Joseph Munoz, Assistant Director of Public Works, City of El Cerrito.
17. Ken Robbins, Brucher & Shiver, Attorneys for Niles Sand and Gravel Company.
18. E. M. Smitten, Supervisor, California Department of Transportation (CALTRANS).
19. John Sustal, Marine Biologist, Corps of Engineers.
20. George Walton, Maintenance Department, BART staff.

ENVIRONMENT PROJECT

PHASE I DOCUMENTATION

- ④ Interpretive Summary*
- ④ Environmental Impacts of BART*
Interim Service Findings
- ④ Acoustic Impacts of BART*
Interim Service Findings
- ④ Impacts of BART on Air Quality*
Interim Service Findings
- ④ Impacts of BART on the Natural
Environment*
Interim Service Findings
- ④ Impacts of BART on the Social
Environment*
Interim Service Findings
- ④ Impacts of BART on Visual Quality*
Interim Service Findings
- ④ Theory Background for Study of BART's
Impacts
- ④ Pre-BART Data Analysis
- ④ Community Monitoring
- ④ BART and Its Environment:
Descriptive Data
- ④ Environment Project
Research Plan*

STUDY PARTICIPANTS

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DeLeuw, Cather & Co.
Bolt Beranek & Newman Inc.
TRW, Inc.
Curtis Associates
Dr. Martin Wachs
Dr. Frances M. Carp
Dr. Eugene Grigsby

Performing Organization

Metropolitan Transportation Commission

Sponsoring Organization

United States Department of
Transportation
United States Department of Housing
and Urban Development

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